DIGEST OF THE

PROCEEDINGS OF THE FIRST CONFERENCE OF THE

International Society of Sugar Cane Technologists

HONOLULU, AUGUST, 1924

An International Conference of Cane Sugar Men

Meeting as the sugar section of the First Pan-Pacific Food Conservation Conference, representatives from various parts of the cane sugar world held discussions on technical problems of common interest, July 28 to August 14, 1924.

There were thirteen sessions in all. The subjects which received attention are listed as follows, with the names of those presiding as leaders of the discussions:

July 29—Sugar Cane Breeding (continued August 5), E. W. Brandes.
July 30—Sugar Cane Quarantine, H. L. Lyon.
August 1—Methods of Cultivation, Hunter Freeman.
August 4—Varieties and the Jeswiet Identification System, Mario Calvino.
August 5—Cane Diseases, D. S. North.
August 6—Bud Selection, H. F. Clarke.
August 6—Cane Entomology, O. H. Swezey.
August 7—Soils and Fertilizers, Kintaro Oshima and G. R. Stewart.
August 8—Rodent Control, C. E. Pemberton.
August 11—Factory Engineering, Norman Kay.
August 11—Factory Operation and Control in Sugar Cane Factories, W. R. McAllep.
August 13—Irrigation, Wm. P. Alexander.

Those who participated in the discussions, listed by countries, were:

Australia—

M. S. Barnett, Head of Technical Field Section, Colonial Sugar Refining Company.
Hunter Freeman, Field Officer, Colonial Sugar Refining Company.
D. S. North, Plant Pathologist, Colonial Sugar Refining Company.

British West India—

British West India Committee represented by Mr. Robt. Catton of Honolulu.

Continental United States—

E. W. Brandes, Pathologist in Charge, Sugar Plant Investigations, U. S. D. A.
T. D. A. Cockerell, Professor of Zoology, University of Colorado.
C. L. Marlatt, Chairman, Federal Horticultural Board, U. S. D. A.
Herbert Osborn, Research Professor, Ohio State University.

Cuba—

Mario Calvino, Director, Experiment Station of Chaparra Sugar Company.
Ralph Wood, Manager, Chaparra Sugar Company.

Fiji—

Harry Flockton Clarke, In Charge Agri. Experiments, Colonial Sugar Refining Company.

Formosa—

Migaku Ishida, Chief of Sugar Exp. Sta., Government Research Institute.
Kintaro Oshima, Director, Dept. Agr., Government Research Institute.

India—

R. L. Pendleton, formerly of India, now with University of Philippines.

Mexico—

R. H. Van Zwaluwenburg, Entomologist, United Sugar Companies.

Philippine Islands—

H. Atherton Lee, formerly of the Philippines, now with H. S. P. A. Experiment Station.
R. L. Pendleton.

Porto Rico—

Norman Kay, Chief Engineer, Central Aguirre Sugar Company.

Hawaiian Islands, U. S. A.—

H. P. Agee
W. P. Alexander
J. D. Bond
W. van H. Duker
C. F. Eckart
W. G. Hall
R. H. Hughes
Horace Johnson
Ernest Kopke
Y. Kutsunai
H. Atherton Lee
H. L. Lyon
W. R. McAllep
W. L. McCleery
W. W. G. Moir
S. S. Peck
C. E. Pemberton
J. Lewis Renton
John A. Scott
Twigg Smith
Walter E. Smith
J. B. Steffee
G. R. Stewart
O. H. Swezey
J. A. Verret
J. W. Waldron
John M. Watt
F. X. Williams
J. N. S. Williams

Factory Operations (By W. R. McAllep)

On Monday, August 11, the program of the sugar section of the Pan-Pacific Food Conservation Conference was given over to discussing factory operations. In the morning Mr. Norman Kay, Chief Engineer of Central Aguirre, Porto Rico, led the discussion from an engineering standpoint. In the afternoon session technical considerations and chemical control were taken up with W. R. McAllep leading the discussion.

Mr. Kay gave an interesting talk on grooving with particular reference to handling returned settlings from the Petree process. The problem was solved by replacing the customary 60° grooving with grooving of 37½° angle and ½ inch pitch. The extraction was higher than before the Petree process was installed but moisture in bagasse was in excess of 50 per cent.

Mr. Ralph Wood, administrator of the Chaparra estate of the Cuban-American Company, spoke of milling under Cuban conditions. On account of an

ample supply of cheap cane and a limited grinding season, extraction is considered secondary to capacity. Double crushers with 60° grooving, 3-inch pitch on the first and 1.5-inch pitch on the second, together with comparatively coarse grooving on the following units, have been found the best solution of this problem of passing a large tonnage of cane through the mill.

Mr. Barnett, of the Colonial Sugar Refining Company, spoke of milling practice in Fiji and Australia. The type of shredder known in Hawaii as the National is used in many mills. Extraction is obtained by a combination of milling and diffusion. In some factories long maceration baths, similar to those at McBryde Sugar Company are used. In other factories large annular drums containing revolving rakes are installed between the mills. In both cases the apparatus is kept partly filled with maceration water. The partly crushed cane averages about fifteen minutes in passing through them. The maceration baths are kept hot to prevent bacterial action and lime is added to reduce inversion.

Mr. Duker spoke on the importance of having Krajewski crusher rolls mesh properly.

Under the subject of milling practice in Hawaii, Mr. Hall spoke on the advantages of the Searby shredder.

Discussion centered largely on efforts during the last few years to improve mill sanitation, including replacing the old slat conveyors with the Ewart, Ramsey, and Meinecke types, the installation of juice pans with steep sides under the mills, the use of antiseptics around the mill and efforts to overcome the objectionable features and deficiencies of the conventional type of juice strainer, including returning the juices used as maceration without straining, the type of pump used for this purpose and the Peck strainer.

Mr. Kopke discussed centrifugal separation applied to handling settlings and other factory problems.

The afternoon session was opened by outlining the work of the Sugar Technology Department of the Experiment Station of the Hawaiian Sugar Planters' Association.

Under the subject of clarification, Dr. Ishida stated that 8 of the 45 factories in Formosa made white sugar for direct consumption, using the carbonatation process. Dr. Ishida also described the clarification process for use in direct consumption sugar manufacture developed by him at the Formosa Experiment Station. Ammonium and magnesium acetates are used. The increase in purity is as much as 7 or 8 points. The process has been tried out on a factory scale but is not yet used commercially. Filtration was one of the principal difficulties encountered.

The general discussion of clarification included the work in recent years at the Hawaiian Sugar Planters' Association, the Petree process and Dr. Horne's process. Under the discussion of the Petree process it was pointed out that while increases in extraction have been secured after installing it in cases where extraction is comparatively low, in Hawaii with high extractions a loss in extraction has followed its installation. The danger of inversion during the lengthened

settling time was also pointed out. Favorable results in clarification were attributed more to the efficiency of the Dorr clarifier than to the process itself.

In the discussion of Dr. Horne's process, it was brought out that juices are first limed, heated and settled. Sodium phosphate is then added, replacing lime salts with the more soluble sodium salts, after which the juice is resettled. This has interesting possibilities in the way of reducing scale in evaporating apparatus and in reducing ash in the sugar. It is certain that most excellent clarification can be secured in any juices with this process.

During the discussion of refining qualities of sugar the fact was brought out that the Colonial Sugar Refining Company, which refines its own raws, produces sugars of 98.5 or higher polarization. The average polarization in Cuba was stated to be about 96.5.

Determining the amount of sugar entering the mill on the cane carrier was the principal subject discussed under Chemical Control. No satisfactory method has been developed for determining this directly. In Java, the Philippines, Formosa and Cuba it is calculated in approximately the same manner as in Hawaii; that is, sugar in bagasse is added to sugar in the mixed juice, and the sum accepted as the sugar in the cane, undetermined losses at the mill being disregarded. In Fiji and Australia sugar in the cane is calculated from the first expressed juice analysis using the following formula:

$s = \%$ sucrose in juice from front roller of first set;
$f = \%$ fibre in cane;
then,

$$\%\ \text{sucrose in cane} = \frac{s \times (100 - (f + 5))}{100}$$

Efficiencies of different mills are compared on the basis of the ratio of a factor termed "Pure Obtainable Cane Sugar" to the sugar recovery in the bags. The factor "Pure Obtainable Cane Sugar" is calculated as follows:

$s =$ (same as above)
$f =$ (same as above)
$S = \%$ sucrose in cane (as above)
$b =$ brix of juice from front roller of first set
then,

$$B = \text{Brix of cane} = \frac{b \times (100 - (f + 3))}{100}$$

and

$$\text{P. O. C. S. in Cane} = S - \tfrac{1}{2}\,(B - S)$$

In Cuba, boiling house efficiencies are calculated on the basis of Winter's formula. The quality ratio table formerly used in Hawaii is the reciprocal of the value obtained by this formula.

After a discussion of the difficulty in understanding manufacturing data reported from different countries and the desirability of having a uniform basis, the following resolution was adopted:

Be it Resolved, That in view of the difficulty in interpreting the figures obtained in the chemical control exercised in the sugar industry, it is desirable to adopt a uniform system of reporting data obtained in the manufacture of cane sugar, to the end that figures reported in one country may be understood in every other cane-producing region.

Sugar Cane Diseases (By H. Atherton Lee)

Root-rot was the opening subject of the discussion on cane diseases at which Mr. D. S. North, of Australia, presided.

The root-rot of Louisiana was described by Dr. E. W. Brandes of the U. S. Department of Agriculture, Washington, D. C. He stated that R. D. Rands, also of the Department of Agriculture, had found the cause of the root trouble in Louisiana. Dr. Brandes mentioned that he recently visited fields of some of the plantations here on Oahu, and, on Lahaina cane at Ewa Plantation, had found an organism similar to the causal organism of root-rot in Louisiana. A cable had just been received from Dr. K. F. Kellerman of the Department in Washington permitting the release of information, then in press, purporting to establish the cause of root-rot of sugar cane in Louisiana.

Dr. Brandes proceeded to say that in Louisiana small holes were found upon the roots, resulting in the root destruction, and that Mr. Rands had shown that a small mollusc or snail of the genus *Zonitoides* was responsible for these holes. A description of the holes was given.

Mr. Otto H. Swezey immediately brought out the point that investigators in Hawaii were familiar with these snail punctures, and he had mentioned four species of these molluscs in one of the publications of the Experiment Station, several years previously. He stated his view, however, that the work of the molluscs could not be considered responsible for what is called Lahaina disease here in Hawaii.

Mr. H. Atherton Lee pointed out that the injuries resulting from molluscs were not alone associated with root-rot of Lahaina cane; but that some of the healthiest Lahaina cane, as well as Yellow Caledonia, D 1135, and H 109 would often show attacks of the molluscs. Cane affected with these mollusc holes of the roots did not in many instances evidence any indication of Lahaina disease.

Dr. Harold Lyon brought out the same point and also stated that Mr. Cyril E. Pemberton had shown that in addition to the molluscs, a centipede would cause similar holes on cane roots. Mr. Pemberton mentioned the facts leading to the finding of the relationship between the holes and the centipedes. Many of the holes were smaller than those caused by molluscs and were too small to be accounted for in that way. A study of the problem had therefore been made, and centipedes definitely associated with these very small holes.

Returning to the question of the relationship between the molluscs and Lahaina disease it was brought out that the collection of these molluscs was made by Dr. Brandes from the field at Ewa in which Mr. W. T. McGeorge had shown the high salt concentration. Mr. McGeorge had subsequently shown rather

clearly in culture studies that the Lahaina trouble in this field was due to this high salt concentration.

Under these circumstances the injuries resulting from the molluscs were apparently secondary, or at least a minor factor in causing the trouble. Mr. W. P. Alexander, of Ewa Plantation, described the area in which the molluscs had been found and corroborated the statements concerning the high salt concentration of the area.

Dr. Lyon pointed out that there were a number of root troubles; that Lahaina disease which was at one time considered to be due to a single cause had now resolved itself into at least three distinct troubles. He stated that the matter of the molluscs would no doubt be gone into thoroughly.

Mr. Guy R. Stewart related the methods of attack on Lahaina disease by the soil investigators. In several instances salt concentration had been shown by Mr. McGeorge to be high enough to be responsible for what was called Lahaina disease. In another district high acidity with a high concentration of soluble aluminum salts were held responsible for what had also been called Lahaina disease.

Two root diseases of cane were known in Formosa, according to Dr. Migaku Ishida, but he stated that not much progress had been made concerning their nature. In Australia, according to Mr. D. S. North, a root disease occurs which is one of their serious troubles. He related experiments in which they were able to transmit the root disease by butt cuttings. There are apparently several types of root troubles in Australia, according to Mr. North.

Mr. North then pointed out the need for knowledge of cane diseases in the various cane countries; with such knowledge, spread of such diseases to new countries could then be easily prevented. The more serious cane diseases of Australia were listed as follows: Gum disease caused by *Bacterium vascularum;* leaf scald caused by a bacterial organism not yet published upon; Fiji disease, the cause of which is unknown; mosaic disease, the cause of which is also unknown; downy mildew caused by a fungus, *Sclerospora sacchari;* red rot; various root rots; rust caused by the fungus *Puccinia kuehnii;* top rot; leaf sheath rots probably caused by *Rhizoctonia* and *Sclerotium* species; and knife cut.

Mr. North asked Mr. Lee to list the cane diseases of Hawaii and also of the Philippines.

The Hawaiian Islands were stated by Mr. Lee to be rather fortunate, in their comparative freedom from serious cane diseases. Although many planters in Hawaii felt that all cane diseases were present in Hawaii, compared with Australia, Java, India, Formosa or the Philippines this country is fairly free of cane diseases. The diseases here in order of the losses caused at the present time would probably be as follows: Mosaic disease, Lahaina disease, red stripe, eyespot, Pahala blight, iliau, sectional chlorosis, ring spot, pineapple disease of standing cane and leaf freckle. Red rot has been recorded in Hawaii only once; a leaf spot caused by a fungus of the genus *Phyllosticta* was also observed once or twice. Of these diseases, mosaic disease causes little or no loss on most plantations, although on a few plantations attention is necessary to prevent material losses which are now occurring. The other diseases are causing very slight losses throughout the Territory at the present time.

In the Philippines, the following diseases are known: Fiji disease, leaf scald, cane smut, mosaic disease, downy mildew, eye spot, a flowering parasite somewhat similar to the mistletoe that lowers the quality of the cane juices enormously, ring spot, red rot, pineapple disease of cuttings and of standing canes, pokkah bong, sclerotial banded disease, a leaf spot caused by the fungus *Cercospora kopkei,* another spot caused by a fungus of the genus *Pestalozzia,* another leaf-spot caused by a fungus, *Phyllachora sacchari,* rust caused by the fungus *Puccinia kuehnii,* sooty mould, sheath spot caused by the fungus *Bakerophoma sacchari,* wilt caused by the fungus *Cephalosporium sacchari,* and leaf freckle, the cause of which is unknown.

The fundamental policy in cane disease control for the Hawaiian Islands, according to Mr. Lee, was to exclude those diseases occurring in other countries which had not yet reached this country. Control of most of these foreign diseases could be effected but it would cost money and it would be much cheaper to exclude the diseases than to combat them once they became established here.

Dr. Ishida listed the diseases known in Formosa, mentioning especially mosaic disease, red rot, pineapple disease, two kinds of root disease, and many other troubles which are in the course of investigation.

In Cuba, Dr. Mario Calvino, of Central Chaparra, mentioned mosaic disease and a trouble which he called blight.

The question of the importation of cane diseases on bamboo poles, or leaves used as packing material, was raised by Mr. E. M. Ehrhorn, Chief of the Plant Inspection Service in Hawaii. It was agreed by the delegates that such importations were a possible source for the admittance of organisms, possibly of minor importance on bamboo, but under certain climatic conditions or on certain varieties might be serious on cane. It was the consensus of opinion that the matter should be looked into more fully.

Gumming diseases were next discussed by Mr. North. Gum disease in Java was distinct from gumming disease in Australia, but was very similar to leaf scald which occurs in Australia. Leaf scald is characterized by leaf streaks which afford the chief symptom for identification.

These streaks become visible as soon as the leaf unfolds and turns green. The larger ones may even be faintly discerned in white immature leaves unfolded by hand. They occur either on the midrib or on any part of the leaf blade or leaf sheath. Some of them traverse the whole length of the leaf. As they strictly follow the course of the vascular bundles, those located on one side run out on the leaf margin at the top end. But the smaller ones instead of traversing the whole length may fade away after running a certain length. They are straight, well defined, narrow, even streaks, creamy, almost pure white in color. They persist as long as the leaf remains green, but with age they tend to broaden out and become diffused, afterwards withering; this process usually commences towards the leaf tip and works downward. Reddish spots or blotches may also appear on them. Numerous bacteria are found in these streaks in microscopic sections, located in the xylem elements of the vascular bundles.

In the stem, numerous reddened vascular bundles are to be found, more especially in the nodes. They even occur in the embryonic tissues almost up to the

growing point. Shooting of the eyes is most pronounced, even the immature eyes near the growing point usually showing a tendency to shoot. The side shoots display symptoms (leaf streaks, etc.) analagous to those of the main stem. They are particularly valuable for identification purposes in more mature canes, because leaf streaks can often be found on them, when they have been obscured by withering on the leaves of the main stem.

Mr. North also described the leaf streaks of gumming disease. The streaks are not present as a rule when a leaf first unfolds, but they develop in the mature leaves, thus being found chiefly on the older leaves. They occur most commonly towards the leaf tips, but may occur on any part of the leaf blade. In color they are yellow and marked with tiny reddish brown spots. They are fairly straight but have irregular margins and do not so strictly follow the course of the vascular bundles as the leaf-scald streaks do. They keep on growing in length, the older portions withering and the leaf tending to split. Typically, the withered portions occur towards the leaf tip, but often streaks consist of a central withered portion, with a live yellow portion at each extremity. In rare cases, streaks are found present when a leaf unfolds and turns green, then having every appearance of having travelled up from the stalk below. These streaks sometimes closely resemble those due to leaf scald of the broader spreading type, especially if, as sometimes occurs, they are devoid of the brown spots and run the whole length of the leaf.

Dr. Lyon again emphasized the need for keeping leaf scald and gumming disease out of Hawaii, since he believed these diseases would be very serious here.

The matter of sectional chlorosis was brought up by Mr. Alexander. Mr. North stated that they had this trouble in Australia and that it was especially common on the variety D 1135. In Australia it was believed to be associated with cold weather when standing water existed around the central cylinder of the stalk.

Dr. Brandes said they had this trouble in Louisiana and had at first considered the cause of much the same nature as described by Mr. North. Later, however, they obtained the disease in their greenhouses in Washington, eliminating the possibility of its being associated with cold weather. He believed the trouble to be due to either extreme of temperature when there was an accumulation of water in the leaf spindle.

In Hawaii the disease has been reported from Olaa, Honokaa, Ewa and Waianae, according to Mr. Lee, but usually has disappeared without any serious harm, within one or two months. The theory of frost injury, as advanced in Australia, apparently could not be applied to such conditions as exist at Ewa and Waianae. The varieties affected have been D 1135 and H 109.

Sugar Cane Quarantine (By H. L. Lyon)

On Wednesday morning, July 30, the delegates of the cane sugar section assembled at the Territorial Plant Quarantine Station and inspected the laboratory and equipment employed in carrying out the local quarantine regulations.

They then visited the cane quarantine house of the Hawaiian Sugar Planters' Association. This house was not entered but was carefully inspected from the outside. The delegates next assembled in the administration building of the Sugar Planters' Experiment Station and engaged in a general discussion of the subject of sugar cane quarantine. The points of especial interest to Hawaii brought out in the discussion may be summarized as follows:

As the sugar cane plant was not indigenous in Hawaii, all diseases and insect pests specific to this plant now present in these islands must have been introduced from outside sources. It follows, therefore, that had adequate quarantine measures been in force from the very first, cane in Hawaii might still be nearly or quite free from its specific enemies.

Laws regulating or prohibiting the importations of propagating material of sugar cane can be considered detrimental only to the country making these laws. It is no hardship to any cane-growing country to have cuttings of its cane varieties refused entrance into any other cane-growing country.

Travel and commercial intercourse between countries afford many avenues through which cane insects and diseases may be transferred from one country to another. It is quite impossible to close some of these avenues and impracticable to close others by quarantine regulations. It is obvious, therefore, that no practical quarantine can afford absolute protection against the entrance of the insect pests and diseases of the sugar cane into new territory.

While the danger of general dissemination of cane insects and diseases will grow with the increase of travel and commerce between the countries of the Pacific, still the danger will, at the same time, be lessened through the growing knowledge of these pests and the application of successful measures of control in the various cane-growing countries where they occur.

It is quite possible to surround the importation of cane cuttings into a country with such precautions that the liability of introducing insect pests and diseases with the cane will be less than that attending ordinary travel and commercial intercourse. This condition has quite evidently been attained through the quarantine measures now in force in Hawaii.

While there is no case on record where a cane disease or insect pest has been transferred from one country to another on dry cane tassels, still it is quite possible that certain cane diseases may be carried on such material and importations of seed should always be handled with great care.

Sugar Cane Entomology (By O. H. Swezey)

The session of the sugar industry section of the Pan-Pacific Food Conservation Conference occurring on the afternoon of August 6, was devoted to discussions on sugar cane entomology. Mr. Swezey was the leader and at the beginning of the program gave a somewhat lengthy account of the major sugar cane insect pests in Hawaii, the history of their occurrence, whence they came, their habits and the damage caused. The method of controlling these pests by

the introduction of natural enemies was outlined, with an account of the different parasites introduced for the respective pests.

Pest	Introduced Parasites	From
Cane Borer, *Rhabdocnemis obscura*	*Ceromasia sphenophori*	New Guinea
Leafhopper, *Perkinsiella saccharicida*	*Paranagrus optabilis*	Australia
	Anagrus frequens	Australia
	Cyrtorhinus mundulus	Australia
	Ootetrastichus beatus	Fiji
	Haplogonatopus vitiensis	Fiji
	Pseudogonatopus hospes	China
	Ootetrastichus formosanus	Formosa
Root grub, *Anomala orientalis*	*Scolia manilae*	Philippines
Aphis sacchari	Several ladybeetles	Australia
	Micromus vinaceus	Australia
Leafroller, *Omiodes accepta*	*Chalcis obscurata*	Japan
	Microbracon omiodivorum	Japan
	Trichogramma minutum	U. S. A.

Mr. H. Freeman, of the Colonial Sugar Refining Company, gave an account of experiments in the control of the cane grubs in Queensland. The two species most injurious to cane there are *Lepidoderma albohirtum* and *Lepidiota frenchi,* and loss by their grubs often is as much as 60 per cent. The adult beetles have their flights at certain definite seasons, and "it was found that there were two main reasons why any particular field of cane was selected by the beetles for the deposition of eggs. These were: (1) the height of the cane, and (2) the proximity to feeding trees. As an example, it was found that fields of cane which were six to nine feet high at the time of the beetle flight were infested to extent of an average of 6 to 14 grubs per stool; whilst cane which was only 6 to 18 inches high averaged considerably less than one grub per stool. From this a control measure was evolved in which a fast growing variety was planted during the beetle flight and pushed ahead by the use of a suitable manuring program." The beetles went to other fields of higher cane for egg laying and this field grew a crop without infestations. By harvesting fields just before the beetle flight, the new ratoons would also similarly escape becoming infested.

This control measure could not be utilized on all fields on account of various labor considerations. By experiment it was determined that a saturated solution of paradichlorobenzol in carbon bisulphide was 2 or 3 times as efficient as either of the constituents used alone. A mortality of 80 per cent to 90 per cent of the grubs was obtained by using this fumigant. The increased yield obtained due to the fumigation made it a profitable investment. This fumigation had no detrimental effect on the growth of the cane providing it was over 4 or 5 months old. Younger cane was seriously affected.

Mr. Barnett, also of the Colonial Sugar Refining Company, told of the cane borer Tachinid being established in northern Queensland, and that it is being distributed to other parts of the State. He also told of its being established and doing well on the Rewa River, Fiji, but that it has not succeeded on the opposite side of the island, though continued efforts have been made to establish it there. The borer has destroyed as much as one-third of the season's sugar crop at one

center. Referring to a recent report by Mr. Veitch, Entomologist of the Colonial Sugar Refining Company, Mr. Barnett discussed some minor pests of sugar cane in Fiji. Among them was the armyworm, and he spoke very highly of the value of the mynah bird in preventing armyworms and grasshoppers from becoming extremely destructive pests.

Mr. Ishida, Chief of Shinka Sugar Experiment Station, Formosa, read two papers, one on "The Application of *Metarrhizium anisopliae* for the Control of *Allisonotum impressicole* and Allied Beetles," in which it was shown that the use of the fungus reduced the number of beetles and grubs about 50 per cent; the other paper was on "The Application of *Phanurus beneficiens* Against Stalkborer and its Result." This is an egg-parasite introduced from Java in 1916, and it has succeeded so well, along with other egg-parasites already present, that at present the damage to the cane from stalkborers is not serious.

Professor Osborn, of Ohio State University, who has made much study of leafhoppers and their economic importance, cited cases of the migration of some species from tropical America north into the United States, and warned of the likelihood of such species becoming pests in the new places they invaded. He said that in a recent letter from an entomoligist in Africa, the corn leafhopper was said to have been found infesting cane. It has never yet been known to do this in Hawaii.

Dr. Williams, who had recently returned from a two years' parasite trip in various South American countries, read a paper on "Insects Affecting Sugar Cane in South American Countries." In this paper the worst pests in various places respectively were: Barbados—root grubs, *Phytalus smithi* and *Diaprepes abbreviatus;* Trinidad—the froghopper, *Tomaspis varia;* British Guiana—moth borers, *Diatraea* spp.; Brazil—froghoppers and *Ligyrus* beetle; Ecuador—moth borers, *Diatraea* spp. and weevil borer, *Metamasius.* Many other minor pests were mentioned. The most of these cane pests are insects native to the regions, and previously feeding on other plants, but have taken to feeding on cane after the introduction of the latter by man. Some of them are partially controlled by natural enemies.

Mr. Kay stated that the principal cane pest in Porto Rico is the white grub.

Professor Cockerell, of the University of Colorado, stated that he had noticed by a report from the entomologist in Egypt, that the mealybug, *Pseudococcus sacchari,* was the worst cane pest they had there, and that it really threatened the prosperity of the sugar industry in Egypt. While in Madeira Islands a few years ago, Professor Cockerell had found this same mealybug, but exceedingly scarce, apparently being destroyed by the larvae of a small *Leucopis* fly. This should be worthy of investigating further, for it might be that the fly could be introduced to Egypt or other countries desiring enemies to this particular mealybug.

Mr. Pendleton reported termites to be the worst cane pests in Gwalior State, India. They often eat the seed before it begins to germinate. If they do not attack the cane until it is pretty well grown, they work up through the stool in the inside of the cane, filling the stalk with mud as they go. Many insecticides have been tried, but all ineffectual. The second pest is the cane borer.

In the absence of Mr. Van Zwaluwenburg, of Los Mochis, Mexico, Mr. Swezey presented for him a paper on the "Insect Enemies of Sugar Cane in Mexico." Two Pyralid moth borers, *Chilo loftini* and *Diatraea lineolata,* were mentioned as the only serious enemies of sugar cane in the state of Sinaloa, the former being by far the more important. No field methods for controlling it have been found. It infests many grasses, also corn, sorghum, and rice. A few native parasites attack this pest, chief among which is a *Chelonus* that has been known to parasitize as high as 23 per cent. Although second in importance, *Diatraea lineolata* has been known to infest from 35 per cent to 60 per cent of the cane stalks. It is primarily a pest of the plant cane. This is better controlled by natural enemies than *Chilo.*

The eggs are often parasitized to the extent of 70 per cent by *Trichogramma minutum.* In one state a Braconid, *Apanteles diatraeae,* has parasitized as high as 50 per cent. Attempts have been made with introduction of four parasitic flies, two from Cuba, one from Vera Cruz, and one from New Orleans, but so far none of them have been recovered. Minor cane pests in Mexico are: armyworms, leafhoppers, froghoppers, Membracids, the cane lacewing, mealybugs, and a weevil borer, *Sphenophorus incurrens.*

Rodent Control (By C. E. Pemberton)

In the session of the sugar section of the Food Conservation Conference devoted to rodent control, it was of particular interest to learn:

1. That rats actually do cause serious losses to cane in other countries. For instance, Mr. M. S. Barnett, of the Colonial Sugar Refining Company of Australia, stated that in 1921 a loss of 4 per cent of the total crop at two of their Australian mills, was attributed to rat activities.

2. That systematic poisoning has been proven effective in rat control in Australia and Cuba, though it has not been so extensively conducted as in Hawaii.

3. That phosphorus is the favored poison in Australia, and strychnine in Cuba. Barium carbonate has apparently not been tried in other countries to any great extent.

4. That rats are not so chronically serious in other cane countries as in parts of Hawaii, and that this condition is probably owing to the presence of natural rodent enemies such as snakes, owls, and hawks, in those countries. Mr. H. Freeman referred to the carpet snake of Australia, stating that it was common in some cane fields and that he had in many instances found the remains of rats inside them. Mr. Barnett also stated that these snakes had been seen to catch rats in buildings in Australia. They are not poisonous. Mr. Wood, of Cuba, also referred to two non-poisonous Cuban snakes which are said to be good ratters. Dr. F. X. Williams noted a non-poisonous British Guiana snake known as the "Yellow Tail," which is considered a very good rat catcher.

Interesting mention was also made by Mr. Barnett of useful hawks in Australia; by Dr. Williams of a beneficial bird of prey, the Caracara of Ecuador; by Mr. Wood of an iguana, owls, and hawks, of Cuba; and by Mr. Freeman of a so-called iguana of Australia, and of useful hawks. All admitted that these various natural enemies of rats had a weakness for chickens.

5. That rats in Australian cane fields damage cane only in sections of fields adjacent to permanent water supply. This point, brought out by Mr. D. S. North, is of particular interest, because rat damage in Hawaiian cane fields shows no relation, so far as observed, to the availability of water.

Sugar Cane Breeding (By Twigg Smith)

The good results that have attended careful crossing of sugar cane varieties is creating more interest in this type of seedling propagation.

The object of all cane breeding work is to obtain a cane which will have a combination of the qualities that are necessary for the production of a high sugar yield. Many canes otherwise good are weak in stooling or subject to attacks by disease.

Again, a hardy, heavy tillering cane may not produce enough sugar to make it a commercial cane.

The combination of good qualities of different varieties, then, would constitute the super-cane.

An endless amount of effort spent year after year in producing hybrids, by any method, from any two varieties, has little chance of success in producing the super-cane unless (a) proper study is given to the inherent characteristics of the parents; (b) their behavior under climatic conditions where the seedlings are to be grown commercially; (c) whether their characteristics, desirable and undesirable, are capable of being transmitted to their hybrid offspring.

Already certain characters and qualities of sugar cane have proved to be transmissible.

The discussion for the most part was by men actually engaged in sugar cane breeding work. The outline presented by Dr. Brandes for thorough discussion of the subject follows:

1. Selection of parents.
2. Varieties naturally inclined to bloom.
3. Environmental conditions affecting blooming or maturity.
   a. Latitude, daylight.
   b. Altitude.
   c. Temperature.
   d. Drought or excessive rain.
4. Technique of crossing.
   a. Methods for determining viability of pollen:
      (1) Iodine test.
      (2) Germination on stigmas of other plants.
      (3) Germination on sugar solutions.
   b. Methods for collecting and preserving pollen.
   c. Periodic viability of pollen during blooming season.

d. Methods of applying pollen:
   (1) Dusting.
   (2) Suspending male panicles.
e. Diurnal variation in opening of florets.
   (1) Receptive period of stigmas.
f. Protection of fertilized flowers against contaminating pollen:
   (1) Cloth bags.
   (2) Waxed paper bags.
   (3) Isolation by distance.
g. Harvesting of seed:
   (1) Bagging previous to maturity.
h. Viability of perfect seed:
   (1) Time to plant.
   (2) Time required for germination.
i. Methods of planting:
   (1) Rate of planting and position in relation to medium.
   (2) Soil.
   (3) Water requirement.
   (4) Provisions for preventing seed mixtures or pot contaminations by wind.
j. Transplanting—elimination of undesirable seedlings.
k. Packing seed for shipment.
l. Uniform methods for designating parents and time of producing seedlings by standard record.

Dr. E. W. Brandes said: "If we hope for progress in the way of actually improved varieties we have to go into breeding much deeper than just taking any two canes and crossing them: we must make a study of the possibilities that lie in the various varieties and fit them in with the various problems that have to be met. Conditions may arise, such as the introduction of a new disease, which may make new varieties necessary."

Selection of Parents: Under this heading it was stated that each country had its disease troubles, and the natural desire is to get a cane that would be immune to disease and at the same time be a good sugar producer.

In Hawaii, efforts are being made to combine the desirable characters of H 109, Badila, and D 1135 on one side, with the hardier, disease-resistant and heavy stooling character of Uba,* in an effort to avoid eye-spot, root-rot, yellow stripe, mosaic, etc. Also the so-called Tip canes are being crossed with D 1135 for higher lands. The Tip canes are vigorous growers at high elevations, but susceptible to mosaic and to red stripe disease. On the other hand, D 1135 is very resistant to eye spot, mosaic, and red stripe disease, and ratoons well, but does not do as well as the Tip varieties above 1500 feet elevation.

We are also trying many field-gathered crosses of H 109 and D 1135.

Mr. Clarke said that in Fiji, Badila is favored as a mother cane, and they would like a combination with such a cane as Yellow Caledonia or H 109.

Mr. Ishida said that in Formosa, their main enemy is sereh, and that effort was being made to get seedlings resistant to it. They are trying several varieties, including Yellow Tip, Rose Bamboo, Badila, and Kassoer.

In Cuba, Dr. Calvino stated that Uba, with D 74 as a male parent, had been useful in producing disease-resistant seedlings. They also imported seedlings from

* The Hawaiian grown cane of the Chinese type called "Uba;" probably not the same Uba as that of other countries.

Barbados and British Guiana. The parentage was not stated. Dr. Calvino said they took a great interest in raising seedlings because the seedlings may show characters which were not apparent in the parent canes.

Mr. Pendleton said that the problem in northern India is to produce a thick cane that will grow well under adverse conditions, notably, low humidity, little irrigation, and serious infestation of termites. In reply to a question, he stated that experiments had demonstrated that the thin-stick North Indian varieties were outyielded by their hybrids having larger sticks.

The question of transmission of susceptibility to disease by parents to seedlings was discussed at considerable length.

Mr. Agee cited the case of H 109, an Hawaiian seedling which is planted to 70,000 acres and gives very high yields and is immune to what is termed Lahaina disease or root rot. This cane is a seedling of Lahaina, which is extremely susceptible to the disease. The seedling H 109 was produced without knowledge of its male parent, but it is thought to be Rose Bamboo or the family to which Rose Bamboo belongs. Rose Bamboo is also susceptible to Lahaina disease. Both Rose Bamboo and Lahaina failed at Ewa plantation, where the world's record yields have been made by their progeny, H 109. Another instance is a cane we call the Uba Hybrid No. 1. We were very desirous of obtaining a cane immune to yellow stripe disease. Following the lead of Dr. Calvino of Cuba, we crossed Uba with D 1135, both parents being commercially resistant to yellow stripe. The hybrid No. 1, however, has well developed cases of yellow stripe or mosaic.

"I think," said Mr. Agee, "that these two cases prove that we cannot be too closely bound by theory in cane breeding."

Dr. Brandes expressed the opinion that the cases mentioned by Mr. Agee were exceptions which prove the rule that like produces like, and that a cane immune to disease has a greater chance to produce immune offsprings. He also pointed out that he had seen yellow stripe on D 1135 in the Philippines.

Mr. Agee stated that at Honokaa a fair percentage of Uba seedlings had yellow stripe disease. It was important, he thought, to note and study these exceptions to what might be expected. It is not the characteristics of the parent canes that we are primarily concerned with, but the characteristics that they are capable of transmitting to their progeny.

Dr. Brandes stated that in trying to get a variety resistant to sereh, in Java, they had crossed their Black Cheribon with Chunnee from northern India. They succeeded in getting seedlings, immune to sereh, but susceptible to other diseases, notably, yellow stripe or mosaic. At the present time they are concentrating on crosses of native canes and the primitive types of sugar cane. The seedlings obtained are then crossed with the heavy-yielding canes, and they have now several promising seedlings, such as P. O. J. 2714, 2725, etc., which are resistant to most diseases. Many of them are commercially immune to mosaic and also the disease referred to as root disease.

Mr. Barnett stated that in the case of a New Guinea variety called Mahona, imported to New South Wales, it was noticed that it had a tendency to die off in the tropics, due, it was discovered later, to a disease called leaf scald. Many seed-

lings had been raised from Mahona, and the majority inherited susceptibility to the disease.

Under the topic of "Blooming or Tasseling," it was brought out that all varieties bloom in Hawaii, and it seems well established that the blooming is best in the medium altitudes. Instances were cited where, on Hawaii, cane did not bloom at 3,000 feet nor at 50 feet, but did bloom between these levels.

It was stated that all varieties bloom at times in Fiji and Formosa.

It seemed generally accepted that anything that checks the growth of the cane seems to cause the plant to arrow, tasseling being considered a normal process of sugar cane.

Under the heading of the "Technique of Crossing," the first discussion was on the methods of determining the viability of pollen. The method favored at present at this Station is to determine by miscroscopic examination if the pollen is spherical and contains granules, in which case it is considered normal. The presence of starch as indicated by the well-known iodine reaction test is in exact relation to the normal state of pollen grains, which are spherical, juicy, and full of granules of starch. It was stated that in Hawaii there was no success in germinating pollen on any of the artificial media tried last year.

Dr. Calvino told of success in germinating pollen on stigmas of other plants, but not in any solution. Mr. Clarke reported a complete lack of success in germinating pollen in any way in Fiji.

Dr. Brandes said that in Florida they had successfully used the moon vine, a species of *Ipomoea*.

In Hawaii, the method of collecting pollen has been to suspend the tassels over a table, which is covered with black paper, and as soon as the pollen had dropped, to sweep it into a container and immediately dust it on the stigmas. No satisfactory method of preserving pollen has been found; rather, it seems to be very fugitive, quickly drying under changes of temperature and humidity. It has never been possible to keep it looking spherical above 10 minutes if exposed to much light.

Under the topic of "Periodic Viability of Pollen," Dr. Brandes pointed out that observation had been made in many places that pollen may be viable at the beginning of the tasseling period and worthless toward the end, and that it is extremely important that we should know just the best time, with each variety we desire to use, to take pollen for cross pollination. The period of non-viability of pollen would be the best time to use that particular variety as a female parent.

No definite data appeared to have been kept as to the best method of applying pollen to the stigmas of the female variety.

Good results have been secured in Hawaii by two methods, tying the male and female tassels together, and by collecting the pollen on paper and brushing it on the stigmas.

Speaking on the variation in the receptive condition of stigmas, Dr. Brandes stated that under local conditions in Florida it had been found that stigmas of sugar cane were receptive from 3:40 A. M. till daylight.

It was generally agreed by those who had used bags to protect the tassels that it is not to be recommended. The tassels are weakened, and germination of the seed is weakened. In general, where a large number of seedlings are wanted, it seems to be considered enough to gather the pollinated tassel in the field from a place where it is fairly reasonable to suppose the desired cross has been effected. Until some method of carrying on artificial cross pollination on a large scale is found, this method of getting crosses will probably continue in most countries.

Dr. Brandes stated that in Florida they now make a practice of waiting a week or so after the last male tassel has been placed in contact with the female, and then put a cloth bag over the pollinated tassel to prevent wasting of prospective seedlings. In Hawaii, the practice is to wait till the fuzz flies from the top of the tassel on being lightly tapped. The tassel is then considered ripe enough to gather. Sometimes the panicle is cut in sections for planting so as to avoid the loss of mature parts.

The time that seed can be held before being planted seemed to vary in each country. In general it seemed that the sooner it was planted the better, although Dr. Brandes told of seed sent from India to Washington, D. C., which germinated very well.

On the question of how long the fuzz should be kept in the hope of germination, it was brought out that cane tassels had continued to give germination for as long as thirty days.

Mr. Kutsunai outlined the Hawaiian method of planting seed, which is to distribute the fuzz on top of sterilized garden soil and sand. The fuzz is kept very moist.

The method of Mr. W. P. Naquin, at Honokaa Sugar Company, of using well-seasoned filter press cake alone, on which the fuzz was spread, has given remarkable results, and probably is as good a medium for getting germination as any used so far.

Dr. Brandes said the U. S. Experiment Station in Florida uses clean fresh-water sand, which is practically sterile, and from which they have had good results.

Mr. Clarke stated that in Fiji they use a glass house, and the temperature ranges from 120° in the day to 60° at night, but even at that they get very excellent germination.

Mr. Agee stated that large cold frames with glass protection were used very successfully in Kohala and Hamakua. These gave a very high temperature.

Steam heat will be tried as a subsoil heat this year in Hawaii, and Dr. Brandes stated it was his intention to try the same in Florida.

Also this year in Hawaii some seedlings will be germinated in a glass house so made that it will be possible to roll the flats out in the fresh air on still, dry days. The time of germination in Hawaii is January and February, which are normally the wettest months.

In discussing the elimination of undesirable seedlings it was brought out that in Fiji, Formosa and in Florida it is customary to discard by inspection, after one year's growth, from 95 to 98 per cent of the canes. In Hawaii, the initial

discard is not so high, usually being from 60 to 80 per cent, sometimes 90 per cent.

Dr. Lyon questioned the advisability of severe elimination of canes the first year, and thought that there was an opportunity for valuable scientific investigation in this connection. Both he and Mr. North cautioned against selecting with a preconceived type in mind, feeling that the superior cane sought in this work may appear in a form different from the commercial canes of today. Mr. North cited Badila as an example of a valuable cane which would be eliminated if grown in competition with other varieties closely spaced about it.

Mr. Moir strongly favored ratooning the original seedling plants and cited the Wailuku seedlings in support of his contention. Initial selections based on plant cane were found inferior by him to canes originally overlooked and afterward selected by him from the old ratoons of the original plants. Mr. Kutsunai pointed out that at the Manoa substation a large number of seedlings were being ratooned this year from the original plants, and he stated that with one exception he had been able to select as plant cane those seedlings which afterward showed to good advantage as first ratoons.

On the question of the spacing of the original plants, it was found that spacing of four or five feet was utilized in Fiji and Formosa and even wider spacing in Florida. In Hawaii, a spacing of plants three feet apart in five-foot rows has been gradually reduced to two feet. On the strength of recent trials of five-foot spacing, however, there is an inclination to adopt this in the future.

Dr. Brandes described a score card system of judging canes with the view of reducing to a minimum the personal equation in selection. Cane breeders in Hawaii, Fiji and Formosa agreed to give this score card system a trial under their conditions. Dr. Brandes laid great emphasis on the strong root system. This, he said, must be considered as a prerequisite of any seedling that is to be retained.

It was also pointed out that when one adopts wider spacing or is slower in eliminating apparent undesirables in a large block of seedlings, he thereby curtails the space that might be devoted to newly propagated ones. To thus reduce the number of germinations is in effect an elimination in itself of those not germinated, and this must be borne in mind in any further study to perfect our methods.

Bud Selection (By Y. Kutsunai)

Mr. Harry Flockton Clarke, of Fiji, presided at this meeting.

That there are mutations of sugar cane is an established fact. The sporting of Striped Mexican into Rose Bamboo, of Red or common D 1135 into yellow-striped D 1135 and bronze-striped D 1135, and finally into the so-called white D 1135; of H 109 into striped H 109, and of Yellow Caledonia into striped Caledonia of various colors, is very well known in all cane countries and needs no evidence to prove its occurrence. The color mutations are naturally the first to be noticed because the mutating qualities are not only clearly visible but also are *independent* of the environmental factors.

The heavy-yielding mutations, which are also thought to exist, as indicated by several tests, are not clearly seen on account of the overpowering environmental influences. How often these heavy-yielding mutations occur and recur in the cane fields is not definitely known at the present state of knowledge of the subject. The frequency with which the striped sport of H 109 occurs may possibly throw some light on the point in question. Eight stools of striped H 109 were found in about 25,000 stools of H 109, or a ratio of 1 in 3,000, roughly. A high-yielding mutation, if rare, as it is thought by some to be, and masked by the environmental factors is not easy to spot. The history and the methods of selecting or isolating high-yielding mutations so far evolved or suggested, and the attending difficulties were well discussed and many points of interest were set forth. A review of these points and ideas follows.

The work of selecting mutations in sugar cane by Mr. A. D. Shamel was begun in 1920. His first activity was that of training a staff of selectionists to develop keen powers of observation. The course consisted of taking a very detailed census of a cane row, noting the position of the stalks, the number of stools per seed piece, the number of stalks arising from a single eye, the length, circumference, and weight of the stalks, the number of joints in the stalks, juice analyses, color types, and uniformity.

When the staff became sufficiently acquainted with the cane plant, the actual selection of superior stools was initiated. The cane selected was always plant cane.

The fundamental idea of the bud selection is to segregate a given variety of sugar cane into its component strains and at the same time to isolate any mutation that may exist or be thrown out in the course of work. From such strains and mutations, the high-yielding lines are to be isolated. These isolated lines may revert back to the original variety or may throw off other new lines.

Two lines of procedure have been developed. In one, a plot of cane is stripped and every stool is examined. Superior stools of cane are chosen for further trial. Due allowance is made for extraneous influences, such as a near-by watercourse or a ditch, proximity to the edge of the field, etc., at the time of judging the stools. The other method consists of covering as wide an area as possible, without the preliminary stripping and picking out of very striking stools, and planting them under uniform conditions for further selection.

In applying the theory of bud selection to practice, two tendencies have been developed. In the one case, the selectionists have laid stress on the so-called types, or conformation of sugar cane. The erect, semi-erect, and the recumbent types of H 109 have been studied carefully in relation to the yielding power of the types. The selectionists of this school hold that a variety of sugar cane, H 109, for instance, is made up of many strains that are well nigh stable. The segregation or resolving of a variety into its component strains is followed by the comparative studies of the segregated strains in order to find the most desirable one. The other school believes that the high-yielding quality of a variety of sugar cane may be correlated with two kinds of characters, visible and invisible. Selection

based on this idea is necessarily very wide in its latitude. Not only all the promising types are accepted, but also all the superior stools are selected for further trial.

The selection work seems to be a rather involved proposition on account of the overwhelming environmental influences which obscure the differences in the yielding qualities of various strains of a sugar cane variety. Consequently the work is now taking a decided turn and the problem of the immediate future is the development of methods by which the disturbing environmental factors may be unified or held in check. The most important cause of the difficulty is the uneven distribution of the elements on which the cane makes growth, such as light, fertility, and water. The "necessities of growth," if allotted to each stool in equal amounts, the inherent characters of the stools become apparent. The method that promises to, in part, fulfill the desired aim, is spaced planting. The selected stools are planted far enough apart so that each stool can have more room for natural development.

Another turn that is taken in the procedure of bud selection work is the study of ratoons. Heretofore most of the work was done in plant crops about a year old. It is reported that a ratoon crop, especially an old ratoon crop, has been noted to be very promising material for selection.

On the whole, the problems confronting selectionists are very much more involved than anticipated. Unless one is fully prepared to meet discouraging results, and unless one has firm conviction and faith in the work, and has originality and resourcefulness to overcome the stumbling blocks that beset the work of bud selection, he is likely to fall short of his goal.

Sugar Cane Cultivation (By J. A. Verret)

The meeting was presided over by Mr. Hunter Freeman, of Australia. Those taking part in the discussion were Messrs. M. S. Barnett and H. Freeman, of Australia; Mr. H. F. Clarke, of Fiji; Messrs. Kintaro Oshima and Migaku Ishida, of Formosa; Mr. R. H. Van Zwaluwenberg, Mexico; Dr. Mario Calvino, Cuba; Mr. R. L. Pendleton, India; and Messrs. H. P. Agee, Guy R. Stewart, W. P. Alexander and J. A. Verret of Hawaii.

We shall outline briefly important points brought out in discussions in the order in which they were presented.

Rotation and Green Manuring: Dr. M. Calvino, speaking for Cuba, pointed out that no rotation is practiced in Cuba, and no irrigation. In a few cases some green manuring is being done experimentally. The velvet bean is used for this purpose with good results. Jack beans have also been tried. The velvet beans are planted broadcast, and plowed in before they mature seed.

Mr. Pendleton, speaking for India, said that agricultural conditions were rather poor in that country. In preparing the land for cane, a wooden, steel-tipped plow is used. This goes down, at the most, about four inches. But the Indian farmers

make up for this to some extent by plowing the land as much as twenty times before planting.

A system of rotation for sugar cane has been recently introduced with promising results. It is one of three years, and starts with sugar cane, planted in the winter season. This grows for one year, and no ratoons are taken. After harvest the land lies fallow until the rainy season, about June or July, when san hemp, *Crotalaria juncea,* is planted. This is plowed under in September, after which the land is planted to wheat. This crop gets one or two irrigations, and is harvested in March or April. The land remains idle until June, when another legume, guar, *Cyamopsis psorolioides,* is planted. This is cut about September, and used for fodder, sometimes being made into silage. Cane follows this, being planted about December, starting a new cycle. Some irrigation is practiced. This applies especially to northern India. The yields are rather small in India, 18 tons of cane per acre being about maximum.

In Fiji there is no irrigation. As a general rule three crops are raised, one plant and two ratoons. This is followed by a green manure crop, black Mauritius beans usually. A fair crop of beans gives about 10 tons of green matter per acre. This is plowed under.

In regard to trash conservation, Mr. Clarke, speaking for Fiji, made the following statement: "Formerly we saved the trash. This was made into piles between the cane rows and after the harvesting of the last crop this accumulation of trash was plowed under. We found a certain benefit from this, but we also found certain disadvantages. The ratoons were hampered in their growth by the banks of trash, which did not rot readily. At that time we were only growing plant and first ratoon crops. Now we do not save any trash except that from the last ratoon crop."

Mr. Van Zwaluwenberg, referring to the western part of Mexico, said that irrigation was the common practice. The fields are ratooned from two to four times. The old lands generally raise but two ratoons. The cane is followed by alfalfa. This grows for two years, cutting the first year and grazing the second. In some cases a short cover crop is put in. This is planted in May or June, and grazed. Cane follows, being planted in the fall or spring. The cane grows for 18 months to 2 years.

In Formosa, some areas are irrigated and some are not. The cane crops consist of one plant and one ratoon. This is followed by a crop of sweet potatoes, and this in turn by peanuts. Cane ratoons very poorly in Formosa.

In Louisiana, a three- or four-year rotation is followed. This consists of one plant crop of cane, one ratoon, and then corn and cowpeas, the cowpeas being plowed under. The four-year rotation is the same except that there are two years of cowpeas and corn instead of one. Cane in Louisiana is about a 9 months' crop. Frosts kill the cane down in winter. These frosts are likely to come along any time from November to March. The average yearly yields of cane vary from about 11 to 18 tons per acre.

In Queensland and New South Wales, the practices are given as follows by Mr. Freeman: "The plant crop is usually about 15 months old and the ratoon crop

occupies the land for 12 months. Generally speaking, we cut two ratoon crops, but on some occasions it runs to third ratoons. This depends upon the prospect of a profitable yield. The trash is certainly not saved. The period of fallow varies, but usually it is only a matter of time sufficient to prepare the land for a subsequent crop. Undoubtedly there are farms that practice green manuring, and they find the benefits of it. It gives handsome yields in Queensland. I think there are various reasons for that, but mainly it serves as a weed control, and supplies humus. The green manure crops are Mauritius beans and cowpeas. Of these the Mauritius bean is undoubtedly the better, for the reason that it holds the ground longer. But it must be plowed under before it produces seed. The ground is well covered for four or five months. We get maximum yields of 10 to 15 tons of green matter per acre. In Queensland we might say that the average cane crop is about 20 tons per acre. We get maximum yields of 60 to 70 tons per acre from year-old crops, but they are exceptional, and these only occur on new lands, recently brought under cultivation. In New South Wales, the climate is colder and the rainfall more even. There we have two-year-old crops of both plant and ratoon cane with yields of 50-100 tons per acre. Very little green manuring is regularly practised, but there is a certain amount of rotation with corn. There is very little done in the way of green manuring, either in Queensland or in New South Wales, but we feel the want of it very badly. There is one point in connection with green manuring that may interest you. For instance, with Mauritius beans, sown broadcast, we use a bushel of seed to the acre, whereas with a drilling machine half that quantity is sufficient, and one man can cover four to five acres per day. It is quite evident that there are many different opinions on the question of rotation practice. Hawaii stands in marked contrast to the other countries in getting increasingly better results without either resting the land or by green manuring. After thirty years of cane growing here, they still get increasing yields from the same land, but in Queensland the opposite is the case. The longer we grow the cane there, the lower the yields, unless we practice green manuring."

Preparing a Field for Planting: New lands in Cuba are not plowed, as these are generally forest lands. Holes are made among the stumps with picks or other sharp instruments, and the cane planted in them. On the lands which are plowed, some of the smaller tractors are used, plowing to less than 12 inches. Oxen are still very extensively used for plowing.

As stated above, the Indian uses a steel-tipped wooden plow for his plowing, with which he may scratch the field 20 times. The other work is largely by hand. The manure is placed in the furrow and well mixed with the soil about six weeks before planting.

The cane is irrigated and has frequent cultivations, gradually filling in the furrow so that by the beginning of the heavy rains in June or July the cane is well hilled.

In Fiji, in plowing in trash, a 4-mule, single-furrow plow, with a 26-inch disk, is used. The furrowing is done with a double mould board to a depth of 7 or 8 inches.

Some steam plowing (Fowler) is done on one plantation. Some tractors are used, the largest being about 45 h. p.

In Formosa, native plows and some tractors are used. The native plows go in about 5 inches. Seven or eight sets of Fowler steam plows are also used. Tractors and steam plows are used on the large plantations only. The small farmers confine themselves to the native plows. Fordson and Case are types of tractors used.

Mr. Freeman gave an interesting resume of the work in Queensland and New South Wales. We quote him: "In regard to Queensland and New South Wales, the plows are of various types. Usually disc plows are used in all preparatory cultivation work. One of the great obstacles in returning humus to the soil in preparatory cultivation has been the difficulty in finding plows suitable for turning under trash or bean crops. Special study has shown that a single furrow disc plow gives best results. The secretary disc is very satisfactory in so far as it has an arched beam which allows of great clearance. But we have modified the first furrow wheel and land wheel by using parts from more up-to-date plows, whilst the rear furrow wheel has been substituted by a disc Coulter. The sharp edge of this Coulter bites into the bottom of the furrow at the junction of the land and the furrow. Thus, by means of thrust, we have achieved what most plow manufacturers try to attain by weight. In consequence of this device, the plow is held to its work. Another point in regard to the satisfactory plowing under of green crops is that the disc needs to be as upright as possible; it must be at least 28 inches in diameter, and the edge kept as sharp as a razor by means of a long bevel and the constant use of a file. The dish of the disc should also be quite pronounced, and the furrow cut by it a full 12 inches. It is just these details which mean successful plowing.

"We believe that the desirable depth of cultivation is about 12 inches, but do not always achieve that. We are using more and more tractors every day. Steam cultivation is not used. My opinion is that a track-laying tractor is the only type to use. Many of the smaller tractors which work with one wheel in the furrow are employed. These are not necessarily preferred, but it is more a case of the inability of small farmers to purchase the larger or more efficient implement. Tractors give us a greater independence of labor by reason of their speed, and this speed is also a factor of importance in fitting in our work with weather conditions. They help us in labor problems, but, I am sorry to say, do not always mean more efficient work."

Planting: In India, whole stalks are planted without cutting, no top seed being used. The fields are irrigated ahead of planting, and the seed buried in the mud by hand (or feet, perhaps is a truer expression).

In Fiji, planting material is obtained from special fields called "seed beds." These are about ten months old when cut, and the whole stalk is used. In planting, the seed is placed 2 feet center to center, with rows 5½ feet apart. The seed is covered with ½ to 1 inch of soil in the rainy season and with about 3 inches in dry weather. When planting is done in the spring top seed is used, as the "seed beds" are not then ready.

These "seed beds" are carefully observed, and if any diseases, such as Fiji disease or mosaic, appear, the field is discarded for seed purposes. On this account both Fiji disease and mosaic appear to be under control, there being but little of either.

Except for this careful inspection for disease, these "seed beds" are not treated differently from the other fields.

In Cuba, as mentioned previously, forest lands are planted with a pick, using short seed. Another method is by means of a sharp, hardwood stick. The laborer walks along, and, at proper intervals, drives the stick in the ground at an angle; the stick is pressed up and pulled out, after which a seed is placed in the hole and the ground pressed about it with the feet. The advantages claimed for this system are that the seed has the benefit of the moisture in the bottom of the hole, and aeration, sunshine and heat at the surface.

Another system being tried out on a commercial scale was described by Dr. Calvino. This is called the Abreu system.

In this system the land is prepared and two seeds are planted in squares eight feet each way and covered with an inch of earth. No holes are used. At harvest only mature stalks are taken, the others are allowed to grow. As we understand this, mature stalks mean all millable cane. The stalks left behind are the immature suckers. Wagons are driven in between the cane rows to haul the cut cane.

In Formosa, both top seed and body seed are used. The seed is planted at an angle of 60° to 70°, and spaced 14 inches in four foot rows.

Mr. Freeman has briefly outlined conditions in Queensland as follows: "In regard to Queensland, usually we take seed from plant crops if possible. Some fields are often planted as seed beds, but no special precautions are taken in regard to them. In many cases seed cane is purchased from a neighboring farmer, but usually it comes from his own farm. We prefer plant cane about 9-10 months old. The seed is cut at right angles to the stalk and the ends are not shattered. This is possible with a soft cane like Badila, but the hardness of H 109 might force us to cut it on a slant as is done in Hawaii. We are afraid of the slanting cut on account of the greater area exposed to drying out. We usually use the whole stalk, but experimental evidence has shown that the tops give increased yields and slightly sweeter juice. These experiments were very carefully conducted. We do not soak the seed cane in water before planting unless the conditions are very dry. It is then a distinct advantage. Hand planting is a thing of the past. Queensland was the inventor of machine planting. It is a question of labor shortage, and I do not doubt but that very shortly you will be using machine planting here. These machines are of simple construction, consisting essentially of a box on wheels with a funnel through which the seed is dropped into the furrow whilst two feet on the rear of the machine cover over the pieces. Usually they work in the furrow, which has been made by a double mould board plow. The main feature about them is that they do the work well and save labor. Two units of labor will do more than five times as much work with the machine as they can with hand planting."

In Louisiana, whole stalks are used for seed. The bulk of these come from the poorest ratoon fields, and up to very recently no attempt was made at selection. Planting takes place in autumn or spring. The autumn planting takes place in September or October, before harvesting begins. The spring planting starts in February and proceeds as fast as weather allows. The seed for spring planting has to be kept over winter and protected from frost. This is done by cutting two rows on one, placing the cane in the furrow and covering with earth several inches deep. This keeps fairly well through the winter. The autumn planting remains in the ground all winter and begins to germinate in February or March, depending on the coldness of the season.

It is now becoming customary to plant a cover crop of sour clover on autumn plant fields. This is turned under when cultivation starts in the spring.

In preparing for planting, the fields are laid out in rows 5 to 6 feet apart. A planting furrow is made in the center of this row, not as deep as the bottom of the furrows between the cane rows, in order to allow for drainage. Wagons with the seed cane are driven in the fields and drop the cane in the furrow, usually two running stalks. Boys follow behind with cane knives, place the cane properly in the row, and cut the stalks into shorter lengths so as to have proper contact with the soil. Disc cultivators follow behind and cover the seed several inches deep.

In the spring the cane is off-barred, and excess dirt removed to allow germination. The off-barring incidentally covers most of the sour clover.

Soils and Fertilizers (By G. R. Stewart)

The meeting of the sugar section which dealt with soils and fertilizers was fortunate in having a group of delegates present from many of the important cane sugar countries of the world. The following cane regions had one or more representatives: Australia, Cuba, Fiji, Formosa, India, the Philippines, and Hawaii. A great diversity of conditions and agricultural practice was revealed in these different regions. It may be illuminating to summarize some of the outstanding observations upon sugar cane soils, and their fertilization, in these widely separated districts.

Australia: The principal sugar cane regions are in New South Wales and in Queensland. Both these districts are part of the coastal plains which extend north and south along the shores of the Australian continent for over 1400 miles. The Queensland cane estates lie in the northern section of this coastal belt, and the New South Wales cane land in the southern.

The soils planted to sugar cane show quite a wide variation. They may be divided roughly into the soils of the alluvial flats and the forest soils. The alluvial flats are deep soils which have been deposited along the banks of the rivers. This land was originally covered by a dense growth of tropical scrub. The soils formed under these conditions are inherently very rich.

The forest soils are, in general, lighter in texture than those of the alluvial flats, though occasional areas of clay occur in this forest land. The greatest dif-

ference between these two soil types is in productivity. The forest soils are notably poorer in yield than the alluvial flats.

There are also limited areas of true volcanic soils which are very similar to some of the soils of the Hawaiian Islands. In general, the Australian volcanic soils are more porous and open in texture than those found in Hawaii. This volcanic land is extremely deep and is inherently rich soil. In all the Australian cane land, moisture is the greatest limiting factor. This open texture of the volcanic soils, therefore, favors the passage of rainfall far down below the roots of the cane plant, and makes the growth of a crop a very great problem in dry weather.

Very little chemical work has been done upon the Australian soils. Dr. Maxwell made a small beginning in chemical work years ago when he was first in Australia. This work did not continue for any great length of time, though for many years government reports have been issued giving the analyses of the soils from various districts. These analyses were not correlated with any field experiments or attempts to determine the productivity of this land. There are no special problems of soil fertility under investigation in either sugar cane region at the present time.

The fertilizer practice which appears to give the best response in Australia is the use of green leguminous cover crops. The trash is usually burned before cutting the cane, in Queensland, and it is becoming very apparent that this is leading to gradual exhaustion of the organic matter of the soil. The use of green manuring crops has not become universal, but there is strong evidence that it is the best treatment for the cane lands of Australia.

At the present time, it is a fairly general practice to apply about 400 to 600 pounds per acre of a phosphatic fertilizer containing about 5 per cent to 7 per cent of nitrogen and 14 per cent to 16 per cent of phosphoric acid. This fertilizer is put on in the drill at the time of planting. If the ratoons are fertilized, it is customary to apply ammonium sulfate, but most of the fertilizer is applied to the plant crop at the time of planting. This practice is believed to stimulate germination of the cane and force the young growth ahead, so that weeds are more easily controlled. The cane crop in Australia is grown for a period of about twelve months, and the average yield of cane is about 25 long tons, or 28 short tons per acre.

Cuba: In Cuba, practically all the sugar cane lands are formed on a limestone base. There are two general types of soils: the dark red soils, and the heavy, black clay loams. For many years it was believed that cane could only be grown upon the red soils. It has now been proven that the best yields are obtained from the black soils. The red soils are very deficient in humus. Green manuring crops such as velvet beans and cowpeas are now being tried to restore the fertility of the older cultivated red soils.

All the cane soils have an apparently inexhaustible supply of lime. It was formerly believed that all that was necessary to restore the fertility of the sugar cane lands was to allow them to go back into wild growth as forest land. This is a very slow process for building up organic matter in the soil. The use of green

cover crops promises to be a much more rapid and effective way to restore fertility.

No extended chemical studies have been carried out on the Cuban soils and no fertilizers are being used at the present time. Nearly all the sugar companies have more land available for cane than is now under cultivation. With this extra land to draw upon, if necessary, and a sugar market which does not warrant a great expansion in production, the tendency in Cuba is to produce cane by the smallest possible outlay. The usual system followed is to cut the cane without firing. The cane tops are used as feed for the bullocks which draw the cane wagons and plow the fields.

The cane trash is allowed to lie in the fields and forms a heavy mulch which effectually prevents weed growth. The plant crop and the first ratoons will ordinarily require considerable cultivation and hoeing. After these two crops have been harvested there is ordinarily sufficient trash to keep down the weeds. The maximum crops obtained are about twenty-five tons of cane per acre. The average crop would probably be from fifteen to twenty tons of cane. The cane fields are ordinarily ratooned for fifteen to twenty years. Fields are not ordinarily replanted till the production of cane has fallen to about eight tons of cane per acre. The crop is grown for about twelve months, all fields being ordinarily cut each year.

Fiji: The best cane lands in Fiji are the alluvial flats, which lie between the low hills bordering the valleys and the rivers flowing through the center of them. A less desirable type of cane land lies further back at the base of the hills, where the soils are partly transported and partly formed of residual material by the weathering of the rocky deposits on the hill slopes. The poorest soils are the upper portions of these slopes, where the land has been subject to excessive washing and erosion.

At the present time, no chemical investigations in soil fertility are under way in Fiji. Many carefully controlled plot experiments have been carried out, comparing local seedlings with standard canes, and contrasting various soil and fertilizer treatments.

As a result of this work, green manure crops have been established as the best fertilizer treatment for the cane lands. On the best lands greater tonnages of cane could be obtained by additional fertilizer applications. The Fiji cane grower has actually found that it is not profitable to raise this maximum crop because of damage which will occur to it before harvest. Badila cane is still the standard variety in Fiji. If a moderate crop of Badila is raised, say about forty tons per acre, the crop will stay erect and will not fall down or lodge before it is cut. With a very heavy crop of Badila, running from 60 to 70 tons per acre, a great deal of the cane will lodge and fall down when rainy or windy weather comes. This results in damage to the stools and breakage and deterioration of the cane. When harvested this heavy crop may have as much as 50 per cent of dead stalks in the field. This has resulted in the policy of raising the maximum profitable crop of about 40 tons per acre, as it actually gives a better return in millable cane and leaves the stools in good condition for ratooning.

For the plant crop, on the rich alluvial lands, it is therefore customary to apply no fertilizer. The medium and poorer lands give a good response to applications of coral sand at the rate of 5 to 10 tons per acre. It is also customary to use about 200 lbs. of sulfate of potash and 300 lbs. superphosphate per acre for the plant crop on these poorer soils.

The ratoons on both good and poor soils receive from 200 to 400 lbs. sulfate of ammonia per acre. The experience, over a number of years, has led the growers to expect an increase of 5 tons of cane per acre for each hundredweight of ammonium sulfate that is applied.

It was formerly customary to save all the trash in order to maintain the content of organic matter in the soil. This also returned an appreciable portion of the potash and phosphates which had been removed by the crop. On account of shortages of labor it has been necessary to abandon this practice on the plant and earlier ratoon crops. The trash is still saved on the last crop harvested before plowing.

As previously noted, the maximum profitable crop for Fiji conditions is about forty long tons per acre. This is commonly obtained from the best land on the plant crop. The plant crop on the poorer lands and the average ratoons will frequently be lower, probably yielding about twenty-five to thirty long tons per acre.

Formosa: The cane soils of Formosa are largely alluvial deposits derived from clay slates and to a smaller degree from sandstone. The resulting soils are in many cases of a heavy clay texture, though loams and clay loams are also found. The soils have nearly all been mapped according to the German system, which was adopted many years ago in Japan.

Considerable chemical work has been done on all the Formosa soils in order to establish any existing relationship between the classification and the composition of the soils.. It is believed this work has developed information of considerable value in planning experimental work upon the fertilization of the cane land.

Extended investigations have been carried out in Formosa upon the reclamation of alkali land. Fortunately, the salts impregnating these soils are largely composed of the sulfates of sodium and magnesium, with smaller amounts of the chlorides of calcium, sodium, and magnesium. It has therefore been possible to reclaim these lands by very simple measures. A combination of drainage and irrigation has now converted some of these former saline areas into some of the most fertile soils in Formosa.

In order to determine the fertilizer requirements of the cane soils, field experiments have been carried on in thirty-four districts where different types of soil are located. In this work the attempt has been made by a study of the yields obtained by all possible fertilizer combinations and the analyses of the plants grown, to try and find the amounts of the different plant foods which the soils are capable of supplying. The general result of this experimental work has been to find that the soils of Formosa are more in need of nitrogen than of phosphoric acid or

potash. Some limited areas respond to phosphates, but very little return has been obtained from the application of potash.

One of the first studies undertaken in work upon fertilization in Formosa was the determination of the coefficient of availability of each of the constituents used in the commercial fertilizers. A great deal of work was done along this line and coefficients are now available for each of the commercial materials, when used under Formosan conditions.

The nitrogenous fertilizers most commonly used are ammonium sulfate and soya bean cakes. Some Chile saltpetre has been used, but there is considerable prejudice against its use because of possible loss from the heavy rains.

Green manuring is now considered one of the most valuable practices in Formosa. It has been calculated that a good green manuring crop will supply about 31 pounds of organic nitrogen per acre. It is now a common practice to grow a green cover crop at least once in three years.

It was formerly customary to burn all the cane trash, but latterly the attempt has been made to have the farmers return the trash to the soil. Where this practice has been followed, remarkable improvement has been noted. This is probably due to the great change which is made in the physical condition of the soil by working in the partly decomposed cane leaves. The Formosan soils are generally extremely heavy in texture. The cane ordinarily produces a poor root system in such land. After considerable organic matter is incorporated in this heavy soil, it becomes notably more loose and friable, and the resulting root system is far more extensive.

India: Sugar cane is grown in India upon a considerable variety of soils. The best cane lands are deep alluvial deposits, such as those which occur along the banks of the Ganges River. These soils are sandy loams to silt loams. Around Pusa, cane is grown upon a group of fine silty loams, which frequently may contain as much as 40 per cent of calcium carbonate. Going farther west, there are older alluvial soils which frequently contain undesirable amounts of soluble salts. In central India, there are many areas of heavy clay adobe, upon which cane is being grown.

In general, the soils of India are low in nitrogen and low in organic matter. This is not surprising when one reflects that these soils have been under cultivation for many hundreds of years. There has never been any general use of green manuring crops. Small amounts of cow manure are applied where it is available. A little oil cake has been used in some districts. A few of the more progressive commercial plantations are now purchasing ammonium sulfate. The native cultivators of India work their land to a very shallow depth, stirring the soil for a few inches with a small wooden plow. A field may be plowed in this way as much as ten or twenty times before the crop is finally put in. This is believed to cause considerable nitrogen fixation by azotifying organisms.

The cane yields obtained by these agricultural methods are very low. Exact figures are not readily available, but the yields are probably lower than those obtained in the other important cane sugar countries.

Philippines: There has been more work done on the soils of Negros than any other island of the Philippine group. This island also produces the greater portion of the cane crop. The soils of the western portion of Negros are derived from volcanic lavas, while in the eastern part of the island they have been formed from limestone.

It is only recently that fertilizers have been used in the Philippines. A number of series of experiments have been carried out and all have shown a notable increase from nitrogenous fertilizers. Very little gain has been obtained from either potash or phosphates. The principal nitrogenous fertilizer now employed is ammonium sulfate. Most of the mixed fertilizers which are being applied contain potash and phosphates, as well as nitrogen. These complete mixtures are being put on as crop insurance, in the absence of more extended experiments to show whether potash and phosphates may sometimes be required.

The best yields obtained in Negros will average about one and three-quarter tons of sugar per acre, for a twelve months crop.

Hawaii: The soils of the Hawaiian Islands are almost entirely volcanic. They are derived from a limited group of rocks, the so-called basaltic lavas. The characteristics of these rocks are: a comparatively low content of silica, a high content of iron and aluminum, and a considerable content of calcium and magnesium. The soils formed from these materials have largely been weathered in place and are nearly all residual soils. There are very limited areas of alluvial soils such as are commonly found in the great valleys of the mainland of the United States.

In texture, the Hawaiian soils tend towards the heavier types, loams, silt loams, clay loams, and clays. It should be explained that there are no true clays formed of potassium aluminum silicate, in the Island soils. The clay-like materials consist of the hydrated oxides of iron and aluminum. This gives a light soil of comparatively low specific gravity. The result is a spongy open texture which allows heavy rain to percolate through the soil with ease. There is very little tendency for such a soil to puddle or pack down. We never have any plow sole or hard pan formed in the Island fields.

It was formerly believed that exact deductions as to fertilizer requirements could be drawn from determinations of the plant food present in soils. Later work has shown the great variability of composition which exists in most soils. This has caused many investigators to feel that all such determinations are valueless. With the modern work that has been done in plant nutrition, we have come to feel that the one thing we can draw deductions from is an actual deficiency in any important limiting plant food.

Extensive work has been carried out at the Hawaiian Sugar Planters' Experiment Station upon the soils of the various experimental areas located in the different islands of the group. Part of these soils responded to either potash or phosphate fertilization, and part of them were evidently well supplied with both these constituents. The result of this work was to show that chemical determinations could indicate the soils which were most likely to require potash and phosphate fertilization. Such work is likely to be an excellent basis for the location of carefully planned field trials. The information given by such trials is probably the best basis for fertilizer practice.

Besides work on the composition of typical soils, extensive work has been carried on in Hawaii upon the effect of fertilizers upon the soil. No noticeable increase in alkalinity of the soil or harmful effect from the heavy applications of fertilizers have been detected. Investigations have also been made on the influence of slightly saline irrigation waters.

At the present time, the principal chemical investigation at this Station is a study of the factors underlying the occurrence of root rot. We are studying the relation of occasional accumulations of salt and the occurrence of high acidity to the susceptibility of varieties like Lahaina cane to root troubles.

In considering fertilizers for sugar cane in Hawaii, we may say there is practically always a response to nitrogenous fertilizers. The one exception to this statement is Grove Farm Plantation on Kauai. Owing to the cane area available on this plantation, it is customary to fallow the fields for about three years before replanting. The cover crop used is either the native wild legumes or pigeon peas. On the plant crop following this fallow period, no response is obtained to applications of nitrogen.

The amount of fertilizer used in the different districts in the Hawaiian group varies with the size of the crop that is ordinarily obtained. The field experiments of the Agricultural Department of this Station have helped to establish the profitable limits of fertilization in each section.

A large part of the plantations are using either complete fertilizers or mixtures which include several forms of nitrogen in combination with phosphoric acid. A portion of these plantations are only putting on potash and phosphates as a matter of insurance. We have one definite region which does give a response to potash in addition to nitrogen. This region is along the Hilo coast. Some of the fields at Ewa have shown a response to potash. There have been a few experiments in other districts where there appears to be a response to potash. There is, however, no uniform widespread need of potash.

Experiments with phospha'es have shown that there is a need for phosphates on a number of plantations. This is especially true of the upper fields in portions of Kauai, Maui, and Oahu.

The Hawaiian system of heavy fertilization is designed to obtain the maximum sugar production from the limited areas of land available for sugar planting. The Island soils appear well adapted to this agricultural practice. It may also be stated conservatively that there is no present evidence of any decrease in productivity from continuous cropping to sugar cane.

PROCEEDINGS

OF THE

SECOND CONFERENCE

OF THE

International Society of Sugar Cane Technologists

Published by

CLUB AZUCARERO DE CUBA

Cuba Sugar Club

HAVANA, CUBA

1927

HAMILTON P AGEE,

Retiring General Chairman of the International Society of Sugar Cane Technologists and Presiding Officer of the Havana Conference.

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Fig. 2. Group picture of the members attending the Honolulu Conference.

Fig. 2*a*. Staff of Cuba Sugar Club Experiment Station.

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FIG. 1

Hawaiian Sugar Planters Association Experiment Station, Honolulu, where the First Conference of the International Society of Sugar Cane Technologists was held in 1924.

FIG. 2

Group picture of the members attending the Honolulu Conference

FIG. 2A.

Staff of Cuba Sugar Club Experiment Station

FIG. 3

Quinta de los Molinos, University of Havana, where the Second Conference of the International Society of Sugar Cane Technologists was held in March, 1927.

FIG. 4

Reading from left to right.—STANDING: *Ph. van Harreveld, Gonzalo Fortún, Jacob Jeswiet, Hamilton Agee, W. A. Orton, E. W. Brandes, Frederick Bates, O. Schreiner, H. W. Turner, G. W. Edgerton, C. B. Gouax, G. G. Chequelin, F. W. Zerban, Mr. Agee, Arthur Rosenfeld, Norman Bennett, Mr. Leonard, D. W. McElroy, George Sauls, W. A. Mace, J. A. Pepper, Goldsmith, W. T. Seymour-Howe, J. Stuntz, G. W. Connon, F. D. Stevens, C. E. Wollman, H. F. Osborne, P. G. Plummer G. A. Woodcock, E. C. Chisholm;* SITTING: *W. R. McAllep, C. F. Bardorf, J. R. Johnston, W. Turner, D. L. Van Dine, G. C. Kaar, D. N. Eaton, R. V. Allison, J. A. Faris, J. H. Wale, G. Phillips, Campbell, Taggart.*

Members attending the Havana Conference

FIG. 4

Reading from left to right. STANDING F. L. Williamson, F. G. Hyleman, Henri Brandt, Lee Camp, B. E. Long, Lopez Dominguez, M. del Valle, H. Yakuoji, W. E. Hinds, C. J. Bourbakis, Marcos Larralde, F. Aldereguía, E. D. Kemper, Theodore Brooks, Stephen Munson, Tsutomo Migake, G. B. Sartoris, S. F. Sherwood, Julio Gomez, W. G. Moir, R. D. Rands, B. F. Barreto, B. A. Bourne, N. H. Storey, R. Clayton, Migaku Ishida, F. S. Earle. SITTING. B. LeBourgeois, Charles H. Thrall, W. P. Jernigan, Jose Santos, H. F. Clarke.

Members attending the Havana Conference

FIG. 5

Sugar Cane Experiment Station at Pasoeroean, Java, where the Third Conference will be held in 1929.

OFFICIAL TOUR OF THE ISLAND OF CUBA

Through the very effective efforts of Dr. Martinez Ortiz, Secretary of State, Dr. Rafael Sanchez Aballi, Secretary of Communications and General Manuel J. Delgado, Secretary of Agriculture, Commerce and Labor, the Cuban Government, with its well-known hospitality, placed at the disposal of the delegates of the International Society the use of a special train, to enable the visitors to make a tour of the Island, and to learn at first-hand the true condition of Cuba's fine industry.

This special train consisted of four Pullmans, a day coach provided with a buffet, where light refreshments were served, and a baggage car. A comprehensive itinerary was planned to give the delegates a representative cross section of the Island and its industry. The map and itinerary which follow show the route of this special train, and the mills at which stops were made.

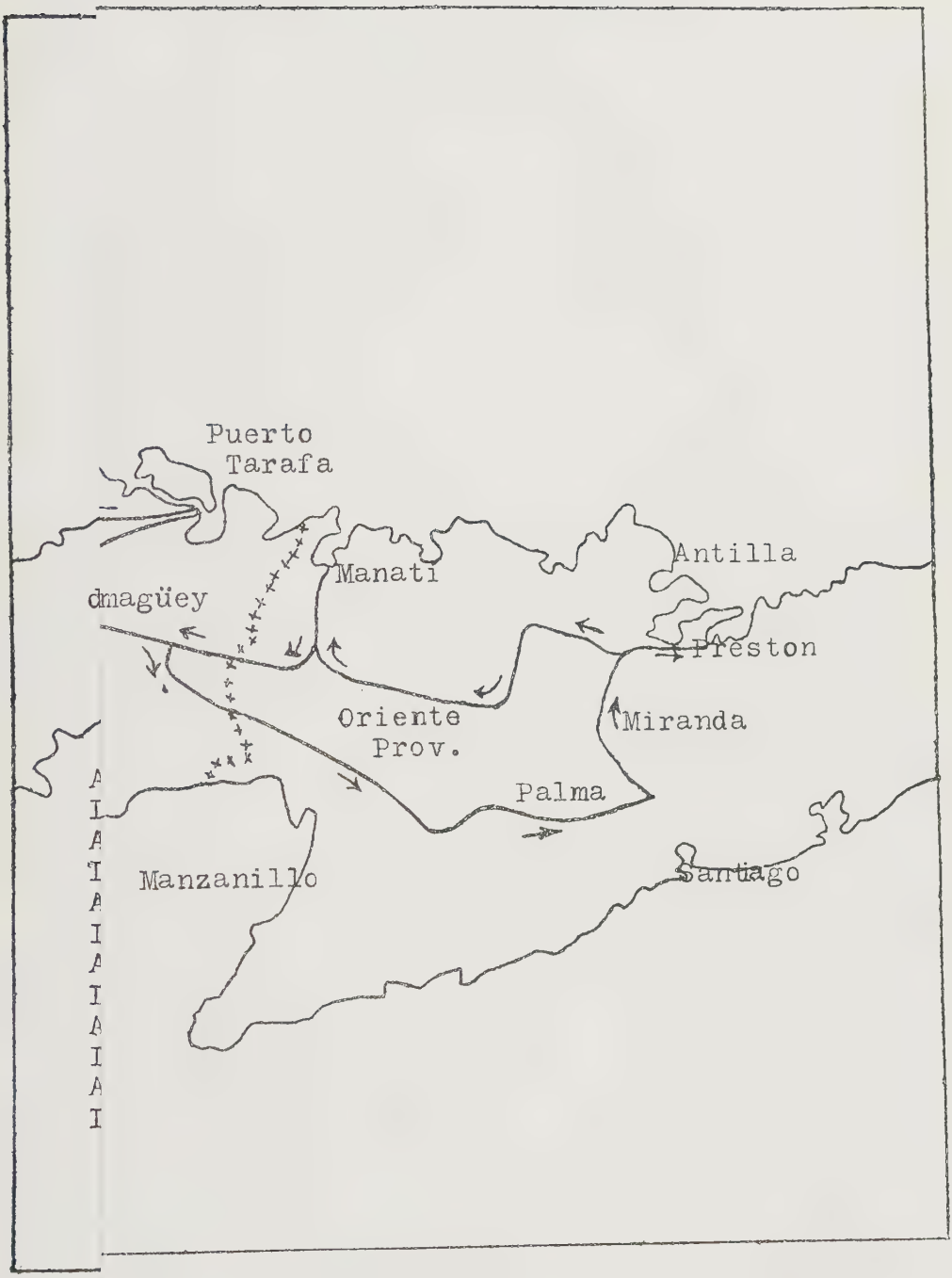
The train left the Central Station at Havana on March 20 at 8:30 P. M. and returned on the 25th at 8:14 P. M., covering in all 2,011 kilometers over the main lines of the railroad and 440 kilometers over the private lines of the sugar mills.

Special mention should be made of the splendid hospitality with which the delegates were received at the various mills, where they were shown the cane lands and the factories, and were feted in the most enthusiastic way. This trip did much to bring about an even better understanding among the members, as they came in closer contact, and were able to continue the discussions started at the meeting in a more intimate way than would have been possible otherwise.

A stop was made at the Cuba Sugar Club Experiment Station at Baragua, where the delegates were able to see the scientific work being carried on by the able staff of workers under the leadership of Mr. D. L. Van Dine.

A detailed description of the trip was published in "Facts Aobut Sugar" of April 2, 1927.

In many ways this excursion was the outstanding feature of the conference, and in expressing the appreciation of the Society for this splendid opportunity of studying Cuba, we express the individual thanks of each member who was fortunate enough to be of the party.


Puerto
Tarafa
Manati
Antilla
dmagüey
Preston
Oriente
Prov.
Miranda
Palma
Manzanillo
Santiago

HORARIO DEL TREN ESPECIAL DE LOS TECNOLOGOS AZUCAREROS

De:	A:	DIA 20-21. En dirección a:	Salidas:	Llegada:	Ferrocarril:	Kms.
Habana	Santa Clara	Central Baraguá	8.35 p. m.	4.10 a. m.	F. C. Unidos	288
Santa Clara	Estación Baraguá	„ „	4.26 a. m.	7.05 a. m.	Cuba Railroad	171
Estación Baraguá	Central Baraguá	„ „	7.06 a. m.	7.19 a. m.	Part. Baraguá	8
Central Baraguá	Estación Baraguá	Central Vertientes	1.45 p. m.	1.59 p. m.	„ „	8
Estación Baraguá	Florida	„ „	2.03 p. m.	2.58 p. m.	Cuba Railroad	49
Florida	Central Vertientes	„ „	3.05 p. m.	3.42 p. m.	Part. Vertientes	37
Central Vertientes	Camagüey	Camagüey	7.04 p. m.	7.45 p. m.	Cuba Rairoad	36
		DIA 22				
Camagüey	Palma Soriano	Central Palma	12.01 a. m.	6.10 a. m.	Cuba Railroad	264
Palma Soriano	Central Palma	„ „	6.12 a. m.	6.43 a. m.	Part. Cent. Palma	28
Central Palma	Palma Soriano	Central Preston	10.16 a. m.	10.45 a. m.	„ „ „	28
Palma Soriano	Herera	„ „	10.46 a. m.	1.14 p. m.	Cuba Railroad	102
Herrera	Colonias Preston	„ „	2.05 p. m.	3.20 p. m.	Part. Cent. Preston	46
Colonias Preston	Herrera	„ „	4.06 p. m.	4.55 p. m.	„ „ „	46
Herrera	Central Preston	„ „	4.56 p. m.	5.41 p. m.	„ „ „	35
		DIA 23.				
Central Preston	Herrera	Central Manatí	5.07 a. m.	6.01 a. m.	„ „ „	35
Herrera	Tunas	„ „	6.15 a. m.	11.10 a. m.	Cuba Railroad	150
Tunas	Central Manatí	„ „	11.19 a. m.	12.23 p. m.	F. C. de Tunas	47
Central Manatí	Colonias Manatí	„ „	2.15 p. m.	2.40 p. m.	Part. Manatí	24
Colonia Manatí	Central Manatí	„ „	3.30 p. m.	3.55 p. m.	„ „	24
Central Manatí	Puerto Manatí	„ „	4.35 p. m.	5.15 p. m.	„ „	20
Puerto Manatí	Central Manatí	„ „	6.01 p. m.	6.30 p. m.	„ „	20
		DIA 24.				
Central Manatí	Tunas	Puerto Tarafa	1.03 a. m.	2.06 a. m.	F. C. Tunas	47
Tunas	Miraflor	„ „	2.09 a. m.	6.01 a. m.	Cuba Railroad	190
Miraflor	Puerto Tarafa	„ „	6.10 a. m.	6.15 a. m.	Norte de Cuba	3
Puerto Tarafa	Central Jaronú	Central Jaronú	8.25 a. m.	10.30 a. m.	„ „	86
Central Jaronú	Colonia Jarocuna	„ Cunagua	2.00 p. m.	3.05 p. m.	Part. Jaronú	51
Colonia Jarocuna	Central Cunagua	„ „	3.25 p. m.	3.40 p. m.	Norte de Cuba	11
Cunagua	(Pina) Cent. Morón	„ Morón	4.20 p. m.	5.45 p. m.	„ „	74
(Pina) Cent. Morón	Ciego de Avila	„ Jatibonico	9.26 p. m.	9.50 p. m.	„ „	21
Ciego de Avila	Central Jatibonico	„ „	10.02 p. m.	11.05 p. m.	Cuba Railroad	44
		DIA 25.				
Central Jatibonico	Santa Clara	Central Tinguaro	12.14 a. m.	2.21 a. m.	Cuba Railroad	110
Santa Clara	Retamal	„ „	2.45 a. m.	5.16 a. m.	F. C. Unidos	113
Retamal	Central Tinguaro	„ „	5.30 a. m.	5.40 a. m.	Part. Cent. Tinguaro	4
Central Tinguaro	América	„ „	7.40 a. m.	7.48 a. m.	„ „ „	3
América	Central Tinguaro	„ „	8.06 a. m.	8.11 a. m.	„ „ „	3
Central Tinguaro	Pijuán	Central España	10.40 a. m.	10.45 a. m.	„ „ „	2
Pijuán	Miraflor	„ „	10.47 a. m.	10.57 a. m.	F. C. Unidos	7
Miraflor	Central España	„ „	10.58 a. m.	11.03 a. m.	Part. Cent. España	4
Central España	Perico	„ Cuba	12.07 p. m.	12.21 p. m.	„ „ „	9
Perico	Piraña	„ „	12.25 p. m.	12.58 p. m.	F. C. Unidos	29
Piraña	Central Cuba	Central Cuba	1.03 p. m.	1.08 p. m.	Part. Cent. Cuba	2
Central Cuba	Navajas	Habana	4.08 p. m.	4.25 p. m.	„ „ „	3
Navajas	Habana	Habana	4.30 p. m.	8.14 p. m.	F. C. Unidos	169
						2,451

RESUMEN DEL KILOMETRAJE RECORRIDO:

F. C. de Servicio Público:	Kms.
Unidos de la Habana	606
Cuba Railroad Co.	1,116
Norte de Cuba	195
Tunas	94
	2,011

F. C. Particulares:	Kms.
Central Baraguá	16
„ Vertientes	37
„ Palma	56
„ Preston	162
„ Manatí	88
„ Jaronú	51
„ Tinguaro	12
„ España	13
„ Cuba	5
	440

Habana, Marzo 27 de 1927.

R. SANCHEZ ABALLI,
Secretario de Comunicaciones.

MANUEL J. PIEDRA,
Auditor de la Comisión de Ferrocarriles.

FIG. 6A.

PROCEEDINGS OF HAVANA CONFERENCE
INTRODUCTION

D. L. Van Dine, Secretary of Proceedings.

Officers and Committees of the Conference.
List of Visitors.
Official Welcome from the Republic of Cuba.
Opening Session
- Address of Dr. Rafael Martinez Ortiz, Secretary of State for Cuba.
- Address of General Jose B. Aleman, Secretary of Public Instruction for Cuba.
- Address of General Manuel Delgado, Secretary of Agriculture for Cuba.

Final Session
- Next Meeting Place and Election of New Officers.
- Motions and Resolutions.
- Regular Standing Committees.
- Special Standing Committees.
- Official Tour of the Island of Cuba.

OFFICERS OF THE CONFERENCE

H. P. Agee	Hawaii	General Chairman.
G. M. Fortun	Cuba	Vice-Chairman.
E. L. Anderson	Cuba	Secretary of Arrangements.
D. L. Van Dine	Cuba	Secretary of Proceedings.

EXECUTIVE COMMITTEE

*	H. P. Agee	Hawaii	Chairman
	G. M. Fortun	Cuba	Vice-Chairman
*	E. W. Brandes	United States	
	D. L. Van Dine	Cuba	
	J. R. Johnston	Cuba	
	Jacob Jeswiet	Java	
*	H. F. Clarke	Fiji	
*	W. R. McAllep	Hawaii	
	Chas. H. Thrall	Cuba	
	James L. Rodgers, Jr.	Cuba	
	E. L. Anderson	Cuba	
	H. T. Osborn	Mexico	
	Julius Matz	Dominican Republic	
	D. M. Semple	Great Britain	

F. W. Zerban . . . . . United States
H. H. Storey . . . . . South Africa
* Migaku Ishida . . . . . Formosa & Japon
Ph. van Harreveld . . . . . Netherlands
R. Clayton . . . . . Australia
C. E. Coates . . . . . Louisiana
F. A. Lopez Dominguez . . . . . Porto Rico
F. L. Williamson . . . . . Florida

SECTIONAL COMMITTEES

I. *Protective Quarantine Measures.*

* E. W. Brandes . . . . . United States . . Chairman
J. R. Johnston . . . . . Cuba . . . . . Secretary
Joaquin Ruiz Mesa . . . . . Cuba
* H. F. Clarke . . . . . Fiji
T. Miyake . . . . . Formosa
W. A. Orton . . . . . United States
S. C. Bruner . . . . . Cuba
D. L. Van Dine . . . . . Cuba

II. *Insect Pests of Sugar Cane.* (Including utilization of parasites).

D. L. Van dine . . . . . Cuba . . . . . Chairman
H. T. Osborn . . . . . Mexico . . . . . Secretary
T. E. Holloway . . . . . Louisiana
S. C. Bruner . . . . . Cuba
W. E. Hinds . . . . . Louisiana
Julius Matz . . . . . Porto Rico
A. H. Rosenfeld . . . . . Louisiana
B. T. Barreto . . . . . Cuba
C. F. Stahl . . . . . Cuba
H. K. Plank . . . . . Cuba
C. E. Woolman . . . . . Louisiana
* H. F. Clarke . . . . . Fiji
J. T. Crawley . . . . . Cuba

III. *Sugar Cane Diseases.*

J. R. Johnston . . . . . Cuba
J. R. Johnston . . . . . Cuba . . . . . Chairman
* E. W. Brandes . . . . . United States . . Secretary
H. H. Storey . . . . . South Africa
Julius Matz . . . . . Porto Rico & Santo Domingo
R. D. Rands . . . . . Louisiana
G. B. Sartoris . . . . . Louisiana
C. W. Edgerton . . . . . Louisiana
T. Miyake . . . . . Formosa
J. A. Faris . . . . . Cuba
C. F. Stahl . . . . . Cuba
R. Menendez Ramos . . . . . Cuba
B. A. Bourne . . . . . Florida

	W. T. Seymour-Howe	Queensland	
	J. Alfaro	Cuba	
	A. Bonazzi	Cuba	

IV. *Sugar Cane Varieties.* (Including propagation and selection).

	Jacob Jeswiet	Java	Chairman
*	H. F. Clarke	Fiji	Secretary
*	E. W. Brandes	United States	
	F. S. Earle	Cuba	
	W. W. G. Moir	Hawaii	
	R. Menendez Ramos	Cuba	
	A. H. Rosenfeld	Lousiana	
	G. M. Fortun	Cuba	
	W. T. Seymour-Howe	Queensland	
	Ph. van Harreveld	Netherlands	
	A. Bonazzi	Cuba	

V. *Cultivation and Field Operations.* (Including soil management and the use of fertilizers).

*	H. F. Clarke	Fiji	Chairman
	J. A. Faris	Cuba	Secretary
*	W. W. G. Moir	Hawaii	
*	F. S. Earle	Cuba	
	F. W. Zerban	United States	
	Ph. van Harreveld	The Netherlands	
	Oswald Schreiner	United States	
	W. G. Taggart	Louisiana	
	J. T. Crawley	Cuba	
	F. A. Lopez Dominguez	Porto Rico	
	R. Menendez Ramos	Cuba	
	Julius Matz	Porto Rico	
	F. D. Stevens	Louisiana	
	C. N. Ageton	Cuba	
	R. V. Allison	Florida	
	E. L. Anderson	Cuba	

VI. *Factory Operation and Chemical Control.*

*	W. R. McAllep	Hawaii	Chairman
	G. W. M. Phillips	Cuba	Secretary
*	Migaku Ishida	Japan	
	C. E. Coates	Louisiana	
	P. C. Tarleton	Cuba	
	F. W. Zerban	United States	
	W. D. Horne	Cuba	
	Ph. van Harreveld	Netherlands	
	H. Yakuoji	Formosa	
	H. S. Paine	United States	
	R. Clayton	Australia	
	Frederick Bates	United States	
	M. S. del Valle	Porto Rico	

	H. F. Clover	Cuba
	W. T. Seymour-Howe	Queensland
	C. D. Kemper	Louisiana
	Lee G. Camp	Cuba
	W. M. Grayson	Argentine
	Norman Bennett	Queensland
	Arthur Elsenbast	United States
	D. M. Semple	Great Britain
	Geo. W. Connon	Cuba
	S. George Chequelin	Louisiana
*	Ralph Wood	Cuba
	Chas. H. Thrall	Cuba

* Charter Members.

LIST OF VISITORS ATTENDING THE HAVANA CONFERENCE

FOREIGN

H. P. Agee, *Director, Hawaiian Sugar Planters Experiment Station, Honolulu, Hawaii.*

Jules Godchaux, *American Sugar Cane League, New Orleans, Louisiana.*

Dr. Jacob Jeswiet, *Agricultural University, Wageningen, Holland.*

W. R. McAllep, *Sugar Technologists, Hawaiian Sugar Planters Exp. Station, Honolulu, Hawaii.*

H. F. Clarke, *Field Experimentalist, Colonial Sugar Refining Co., Ltd., Fiji Islands.*

Migaku Ishida, *Ex-Director of Sugar Exp. Station, Consulting Technologist to Japanese Corporation of Sugar Co., Formoss and Japan.*

H. H. Storey, *Plant Pathologist, Dept. of Agriculture, Durban, South Africa.*

W. T. Seymour-Howe, *Queensland Sugar Producers & Queensland Cane Growers' Council, Australia.*

John R. Johnston, *Director of Agricultural Research, United Fruit Co., Boston, Mass.*

Julius Matz, *Pathologist, Central Aguirre Sugar Co., Porto Rico.*

E. W. Mayo, *Editor, Facts About Sugar, New York.*

Reginald Clayton, *Chief Designing Engineer, The Colonial Sugar Refining Co., Ltd., Sydney, Australia.*

F. W. Zerban, *Chemist in charge, New York Sugar Trade Laboratory, N. York City.*

Ph. van Harreveld, *Bureau of Sugar, The Hague, Holland.*

F. A. Lopez Dominguez, *Director, Insular Experiment Station, Rio Piedras, Porto Rico.*

R. D. Rands, *Pathologist, U. S. Dept. of Agriculture, Washington, D. C.*

F. D. Stevens, *Associate Agronomist, Houma, La.*

G. B. Sartoris, *Associate Pathologist, Bureau of Plant Industry, Washington, D. C.*

W. A. Orton, *Director, Tropical Plant Research Foundation, Washington, D. C.*

Sidney F. Sherwood, *Associate Biochemist, Sugar Plant Investigation, Washington, D. C.*

E. W. Brandes, *Pathologist in Charge, Sugar plants, U. S. Dept. of Agriculture, Washington, D. C.*

T. Miyake, *Chief, Section of Plant Pathology, Government Research Institute, Formosa.*

Frederick Bates, *Bureau of Standards, Washington, D. C.*

C. F. Bardorf, *General Superintendent, St. Lawrence Refineries, Montreal, Canada.*

Oswald Schreiner, *Senior Biochemist in Charge Soil Fertility Investigations, U. S Dept. of Agriculture, Washington, D. C.*

Manuel A. del Valle, *Superintendent Field & Fabrication, Central Constancia, Porto Rico.*

R. V. Allison, *Everglades Experiment Station, Belle Glade, Florida.*

D. M. Semple, *The Mirrless Watson Co., Ltd., Glasgow, Scotland.*

S. G. Chequelin, *1667 Soniat St., New Orleans, La.*

E. A. Maier, *Agriculturist, Southern Sugar Co., Clewiston, Florida.*

C. W. Edgerton, *Pathologist, La. State Agric. Exp. Station, Baton Rouge, La.*

W. C. Taggart, *Assistant Director, La. State Exp. Station, Baton Rouge, La.*

C. B. Gouaux, *In charge of sugar cane work, La Exp. Station, Baton Rouge, La.*

W. P. Jernigan, *Florida Sugar Co., Canal Point, Florida.*

Wm. L. Owen, *La. State Experiment Station, Baton Rouge, La.*

B. A. Bourne, *U. S. Bureau of Plant Industry, Canal Point, Florida.*

Louis I. Brill, *President of Stein Brill Corporation, New York.*

Herbert T. Osborn, *United Sugar Companies, Los Mochis, Sinaloa, Mexico.*

T. E. Holloway, *Sugar Cane Insect Laboratory, New Orleans, La.*

Wm. W. G. Moir, *Agricultural Technologist, American Factors, Ltd., Honolulu, Hawaii.*

E. D. Kemper, *Sterling Sugars Inc., Shadyside, Lousiana.*

C. E. Woolman, *Chief Entomologist, Huff Daland Dusters Inc., Monroe, Louisiana.*

Carlos Herrera, *Herrera & Cía., Guatemala City, Guatemala, C. A.*

Arthur Elsenbast, *Celite Products Co., Manager Filtration Department 11 Broadway, New York City.*

John F. Borden, *Oliver Continuous Filter Co., Cunard Bldg., San Francisco, Calif.*

Norman Bennett, *Technologist, Bureau of Sugar Exp. Station, Queensland, Australia.*

Arthur Rosenfeld, *Consulting Technologist, American Sugar Cane League, New Orleans, La.*

E. W. Kopke, *Manila, Philippine Islands.*

P. E. Long, *Mexico.*

F. L. Williamson, *Vice-President, Southern Sugar Co., Clewiston, Florida.*

George W. Agee, *Memphis, Tenn.*

Ralph S. Falkiner, *Australian Club, Melbourne, Australia.*

W. E. Hinds, *La. State Experiment Station, Baton Rouge, La.*

C. E. Coates, *La. State Experiment Station, Baton Rouge, La.*

B. le Bourgeois, *Louisiana.*

Stephen C. Munson, *Napoleonville, Louisiana.*

A. B. Campbell, *Oliver Continuous Filter Co., San Francisco, Calif.*

Wm. M. Grayson, *Tucuman, Argentine.*

F. J. Patchell, *American Cyanamid Co., 535 Fifth Avenue, New York City.*

H. Yakuoji, Formosa.

H. S. Paine, *U. S. Bureau of Chemistry, Washington, D. C.*

LOCAL

General Manuel Delgado, *Secretary of Agriculture, Commerce and Labor for Cuba, Habana.*

Enrique Soler y Baro, *Introductor del Cuerpo Diplomatico de la Republica de Cuba, Cuba.*

R. Martinez Ibor, *Chief, Bureau of Publicity, State Department for Cuba, Habana.*

Gonzalo M. Fortun, *Director, Estacion Exp. Agronomica, Santiago de las Vegas, Cuba.*
Charles H. Thrall, *Vice-President, Cuba Sugar Club, Habana, Cuba.*
E. L. Anderson, *Vice-Secretary, Cuba Sugar Club, Habana, Cuba.*
J. T. Crawley, *Consulting Agriculturist, Sugar Plantations Operating Co., Habana, Cuba.*
C. N. Ageton, *Chemist, Habana, Cuba.*
G. C. Kaar, *Manager for Cuba of Petree & Dorr, Engineers, Banco Canada, Habana.*
Henri S. Brandt, *Executive Secretary, Association of Mill Owners & Planters of Cuba, Habana.*
D. L. Van Dine, *Local Director, Tropical Plant Research Foundation, Central Baragua, Cuba.*
R. Menendez Ramos, *Director of Agricultural Department, Cuban Dominican Sugar Co., Cuba.*
R. Sanchez Aballi, *Secretary of Communications, Republic of Cuba, Habana, Cuba.*
H. K. Plantk, *Associate Entomologist, Tropical Plant Research Foundation, Central Jaronu, Jaronu, Camaguey, Cuba.*
F. S. Earle, *Agriculturist, Tropical Plant Research Foundation, Herradura, Cuba.*
James A. Faris, *Chief Pathologist, Tropical Plant Research Foundation, Central Baragua, Baragua, Camaguey, Cuba.*
A. Molino, *Cuba Cane Sugar Corporation, Habana, Cuba.*
Julio Alfaro, *Manager, Central Portugalete, Cuba.*
F. E. Thurston, *Manager, Central Rio Cauto, Cuba.*
J. H. Wale, *Agriculturist, Beattie Sugar Co., Central Isabel, Cuba.*
W. E. Dickinson, *Habana, Cuba.*
Marcos Larralde, *Habana, Cuba.*
S. C. Bruner, *Chief, Dept. Entomology and Plant Pathology, Estacion Exp., Agronomica, Santiago de las Vegas, Cuba.*
B. T. Barreto, *Jefe de Campo, Central Cunagua, Cuba.*
Edelberto Ebra, *Jefe de Campo, Central Jaronu, Cuba.*
W. A. Powe, *Assistant Superintendent Fabrication, Central Baguanos, Cuba.*
James L. Rodgers, Jr., *Assistant Manager, Central España, Cuba.*
J. A. Pepper, *Assistant Manager, Ingenio Jobabo, Cuba.*
Geo. M. Sauls, *Superintendent Manufacture, Ingenio Jatibonico, Cuba.*
A. G. Floyd, *District Manager, Chilean Nitrate, Habana, Cuba.*
Augusto Bonazzi, *Director, Chaparra Experiment Station, Oriente Cuba.*
A. J. Keller, *Cuba Cane Sugar Corporation, Habana, Cuba.*
Douglas N. Eaton, *Central Baguanos, Oriente, Cuba.*
Paul G. Plummer, *Central Baguanos, Oriente, Cuba.*
C. C. Capdeville, *Punta Alegre Sugar Co., Habana, Cuba.*
A. W. Turner, *Field Manager, Central Jagueyal, Cuba.*
G. W. W. Phillips, *Honolulu Iron Works, Habana.*
W. L. Schurz, *Economic Adviser to the Cuban Government, Habana.*
George W. Connon, *Honolulu Iron Works, Habana.*
Jose M. Santos, *Profesor Auxiliar, Universidad de la Habana.*
A. A. Betancourt, *Profesor de Maquinaria Agricola, Universidad de la Habana.*
Fidel Barreto, *Cuba Sugar Club, Habana.*
A. A. Goytisolo, *North American Sugar Co., Manzana de Gomez, Habana.*
C. J. Bourbakis, *Superintendent Chemist, Fowler Plantations, M. de Gomez, Habana.*
A. B. Gilmore, *Publisher, Edificio La Metropolitana, Habana.*

Pablo F. Carreño, *Administrador, Central Covadonga, Cuba.*
Juan M. Seiglie, *Cultivador de Caña, Vedado, Habana.*
F. Aldereguia, *Habana.*
Theodore Brooks, *Representing West India Committee of London, Habana.*
H. W. Turner, *Central Miranda, Cuba.*
D. W. McElroy, *Habana.*
M. J. Leonard, *Vice-President, Punta Alegre Sugar Co., Habana.*
W. A. Mace, *Central San Antonio, Madruga, Cuba.*
G. A. Woodcock, *Habana.*
E. C. Chisholm, *Habana.*
Joaquin Ruiz Mesa, *Director, Sanidad Vegetal, Habana.*
Ernesto Sanchez Estrada, *Sanidad Vegetal, Habana.*
F. G. Heyelman, *Habana.*
P. C. Tarleton, *Cuba Cane Sugar Corporation, Edificio Barraque, Habana.*
W. D. Horne, *Cuba.*
H. F. Clover, *Assistant Manager, Central Baragua, Cuba.*
Lee G. Camp, *Habana.*
Ralph Wood, *Manager, Central Chaparra, Cuba.*
T. H. Lougher, *Finca "San Antonio", Matanzas, Cuba.*
Julio E. Vasseur, *Habana.*
Chas. A. Beatty, *Sindicato Aleman de Potasa, Manzana de Gomez, Habana.*
Leon Elso, *Cárdenas No. 21, Habana.*
P. W. Evered, *Central Soledad, Cienfuegos, Cuba.*
W. L. Hausman, *Ingenio Rio Cauto, Rio Cauto, Oriente, Cuba.*
Paul R. Hasson, *Fowler & Co., Habana.*
Hugo Hartenstein, *Thrall Electric Co., Habana.*
E. W. Kerr, *Cuba Cane Sugar Corporation, Edificio Barraque, Habana.*
Dr. Ramon H. Martinez, *Presidente, Asociacion de Hacendados y Colonos, Habana.*
Rafael Matacena, *Administrador, Central Carmita, Prov. de Santa Clara, Cuba.*
E. G. Miller, *Sugar Plantations Operating Co., Aguiar 71, Habana.*
David Sturrock, *Central Rosario, Colonia Aguacate, Cuba.*
W. W. Schuyler, *Central Preston, Preston, Oriente, Cuba.*
S. L. Symes, *Central Soledad, Cienfuegos, Cuba.*
J. I. Tims, *Central Hershey, Hershey, Cuba.*
Charles Williams, *J. Z. Horter & Co., Obispo 7, Habana.*
Walter Wedde, *Central La Francia, Los Palacios, Prov. de P. del Rio, Cuba.*
Basil Hone, *Compañia Riera, Toro & Van Twistern, S. A., Habana 86, Habana, Cuba.*
Wiley D. Stephenson, *Representative of The Planter and Sugar Manufacturer, Habana.*
H. D. Lanier, *General Sugar Co., Habana.*
J. J. Seip, *Central Amistad, Cuba.*
Stefano Calcavecchia, *San Juan de Dios 3, Habana.*
Fernando Guerrero, *Sugar Plantations Operating Co., Aguiar 71, Habana*
Marcos de Zarraga, *Central Adela, Cuba.*
Morril B. Spaulding, *Engineer, Habana.*
Graham Granger, *Hershey, Cuba.*
J. A. Massel, *Manager, Kelvin Engineering Co., Habana.*
J. B. Trinler, *United Fruit Co., Preston, Cuba.*
M. de Arango, *Banco Canada 309, Habana.*

Roland H. Hill, *Edificio Robins 510, Habana.*
I. F. Mattson, *Central Preston, Cuba.*
A. J. Schmitz, *Thrall Electric Co., Habana.*
E. A. Brooks, *Central Chaparra, Cuba.*
B. Garnham, *Manager, Central Caracas, Cuba.*

OFFICIAL WELCOME FROM THE REPUBLIC OF CUBA

March, 12, 1927, 11:00 A. M.

A special meeting of the members of the International Society of Sugar Cane Technologists was held at the Hotel Florida, for the purpose of receiving the official welcome of the Republic of Cuba. The representatives of the President of Cuba were presented to the members of the Society by Mr. E. L. Anderson, Secretary of the Cuba Section of the International Society. Sr. Enrique Soler y Baro appeared as the special representative of the President of the Republic of Cuba and gave cordial greetings to the visiting members. He was followed by Sr. R. M. Ibor of the Department of State for the Republic who expressed the importante of the Conference and offered to the visiting members the hospitality of Cuba. Mr. H. P. Agee of Hawaii, General Chairman of the International Society, responded with appropriate remarks concerning the fitness of a meeting of sugar cane technologists in Cuba, because of the importance of Cuba in the sugar world and the favorable natural advantages of Havana and the Island as a meeting place. Remarks were also made by Mr. G. M. Fortun, Director of the Cuban Agricultural Experiment Station, by D. L. Van Dine of the Cuba Sugar Club Experiment Station, Tropical Plant Research Foundation, and by Dr. E. W. Brandes of the Bureau of Plant Industry, Washington, D. C.

PROCEEDINGS

March 14, 1927, Convention opened at 9 A. M.

Mr. H. P. Agee of Hawaii, General Chairman of the International Society of Sugar Cane Technologists, presiding.

Mr. Agee requested Dr. Rafael Martinez Ortiz, Secretary of State for Cuba, representing the President of the Republic, to open the sessions of the Conference.

Address of Dr. Rafael Martinez Ortiz, Secretary of State for Cuba:

DISCURSO DEL EXMO. SR. SECRETARIO DE ESTADO DR. RAFAEL MARTINEZ ORTIZ.

SEÑORES:

El Honorable Señor Presidente de la República me ha ordenado que, en nombre de él, abra este Congreso que para Cuba y para el mundo entero que se interesa en asuntos de azúcar, ha de tener en lo sucesivo grande y trascendental importancia.

Es el azúcar, indudablemente, uno de los productos principales del mundo entero, un artículo de primera necesidad y es claro que deban interesarse en su producción todos aquellos países que tienen la dicha de poder producir un artículo de tan gran importancia para el bienestar de la humanidad. Nosotros somos uno de los grandes productores de ese artículo procedente de la caña de azúcar y, por lo tanto, nos es grato que sea nuestro país uno de los primeros en los cuales se reunan los elementos interesados en la fabricación de dicho producto.

Desde el inicio del descubrimiento de la Isla de Cuba se estableció en ella esa planta rica, que la debemos en nuestro país al propio descubridor Cristóbal Colón. El la introdujo en la Isla de Santo Domingo en su segundo viaje, trayéndola de las Islas Canarias, a cuyas Islas había llegado de España, donde fué introducida por los Arabes. En la India se cultivó primero la caña, pasó a Europa y fué después traída por el propio Colón a América, donde existe hoy como uno de los recuerdos más grandes del que fué genial descubridor de este Continente.

No voy a hacerles a ustedes la historia de la producción azucarera, la cual conocen perfectamente, y también saben que, probablemente, fué la India el lugar donde primeramente se descubrió la planta productora del azúcar. Herodoto dijo que en ese país había una sal que era dulce, esa sal era el azúcar.

En nuestro país se cultivó la caña de azúcar desde un principio y se impulsó en cierto grado el desarrollo de la industria azucarera, pero sin llegar a alcanzar un gran desenvolvimiento hasta que se llevó a efecto la abolición de la esclavitud en algunas colonias, lo cual dió lugar al desarrollo rápido de su cultivo en Cuba; luego vino la guerra de la Independencia y con ella tuvo lugar un descenso lamentable en la producción azucarera, llegando a bajar, de un millón de toneladas por año, a doscientas mil toneladas, mientras que el año pasado nuestra producción ha alcanzado la asombrosa cifra de cinco millones doscientas mil toneladas.

Este año hubiera sido posible superar la cifra indicada si no fuera porque los propios productores Cubanos han querido, en bien de la industria, restringir la producción de ese producto.

Si ustedes hacen un recorrido por la Isla tendrán que ver, con sus propios ojos, la gran cantidad de caña que se encuentra en sus campos, con la que se podría producir, aproximadamente, cinco millones y medio de toneladas.

Contribuye a esta faborable condición la feracidad de nuestras tierras, pues es sabido que, en Cuba, la planta permite cortes sucesivos durante cinco años como término medio, habiendo casos en que llegan a lograrse cortes por espacio de seis y ocho años y hasta más.

Las condiciones naturales del clima y suelo de nuestro país lo hacen altamente propicio para el desarrollo de esa planta de naturaleza insular; no continental.

Nuestros métodos de cultivo, como ustedes podrán apreciar, son aun bastante deficientes y en muchos casos no se emplean los abonos apropiados, ni se atiende, tampoco, a la importante cuestión del regadío, siendo así que como dice el Sr. Alvaro Reynoso, autoridad la más grande en la materia, "La caña es una planta de regadío".

Hasta el presente nosotros no hemos prestado a las palabras de nuestro sabio compatriota la importancia que merecen y casi puede decirse que en la cuestión del regadío no hemos dado un solo paso hacia adelante. Desde el punto de vista industrial, como ustedes saben, Cuba se encuentra a la altura de los pueblos más adelantados y en nuestro país se hallan los centros de mayor capacidad productiva. Además de esas condiciones favorables de nuestro suelo, tenemos otras ventajas que permiten la explotación provechosa de ese cultivo. A pesar de nuestros altos jornales, nos es posible competir con otros países azucareros, donde la mano de obra devenga menores jornales. Nuestra posición geográfica es otro factor muy favorable. En lo que respecta al combustible, por ejemplo, estamos, puede decirse, en el centro de los más grandes países productores de petróleo en el mundo; tenemos a Texas, Mexico, Venezuela y Colombia. Además, no muy lejos de nuestros puertos tenemos el inmenso mercado de los Estados Unidos y otro mercado importante

también: el Canadá, con el cual el volumen de nuestros negocios ha de adquirir mayor auge cada día. Mantenemos fáciles relaciones con Inglaterra y hace tan solo unos días hemos tenido el gusto de inaugurar la comunicación telefónica con Londres, quedando así abierto un servicio rápido de intercambio de pedido con uno de los centros más grandes de consumo, como es Inglaterra.

En estas condiciones es evidente que nuestra posición como país productor de azúcar descansa realmente sobre base sólida. Hemos limitado este año la producción de azúcar, porque consideramos que se trataba de una medida beneficiosa para nosotros y, en general, para los intereses azucareros del mundo. Deseable sería que pudiéramos concertarnos todos y armonizar intereses siguiendo una orientación que permite sostener a buena altura el precio del azúcar, lo cual habrá de resultar en beneficio del mundo entero, produciendo la estabilidad en los mercados.

Por otra parte, la posibilidad de mejorar nuestro cultivo asegura para Cuba todavía un porvenir amplio en las luchas.

Estamos, pues, en condiciones de producir mayor cantidad de azúcar y desearíamos poder llegar a concertarnos entre los interesados en esta industria y así marchar de común acuerdo o hacer todos propaganda con miras a la consecución de condiciones que permitan una lucha honrada y beneficiosa para todos los intereses mundiales. En nombre del Honorable Señor Presidente de la República, declaro abierto este Congreso y hago votos porque los trabajos realizados y el intercambio de ideas que se ha de lograr, redunden en beneficio de los concurrentes, del país y del mundo en general. Los señores congresistas podrán presentar los trabajos en tres idiomas, a saber: el Español, el Inglés y el Francés, pues habrá intérpretes en esos tres idiomas.

The address of Dr. Martinez Ortiz was interpreted into English by Sr. Martinez Ibor of the Department of State for Cuba.

ADDRESS OF DR. RAFAEL MARTINEZ ORTIZ, SECRETARY OF STATE

Gentlemen:

The Honorable President of the Republic has instructed me to open in his name this Congress which will in the future be of grest and trascendental importance for Cuba and for all the World interested in sugar matters.

Sugar is undoubtedly one of the principal products of the entire world, a commodity necessary to life and it is natural that all countries that have the privilege of being able to produce an article which means so much for the comfort of Humanity, be interested in its production. We are one of the great producers of that article extracted from sugar cane and therefore it is a source of pleasure for us that our country is the meeting place of those interested in the manufacture of said product.

That rich plant was established in Cuba since its discovery and we owe it in our country to Christopher Columbus, the discoverer himself. He introduced it in the Island of Santo Domingo in his second voyage, bringing it from the Canary Islands, where it had been brought from Spain having been introduced there by the

Arabs. Cane was first cultivated in India; it was taken to Europe and was afterwards brought to America by Columbus himself, where it exists to-day as one of the greatest monuments to him who was the genial discoverer of this continent.

I am not going to present before you the history of sugar production which you know perfectly, as you also know that probably India was the place where the sugar producing plant was discovered. Herodotus said that there was in that country a salt which was sweet; that sweet salt was sugar.

In our country sugar cane was cultivated from the beginning, and the sugar industry was to certain extent developed but without obtaining great impulse until slavery was abolished in some plantations, which caused a rapid advancement in its cultivation in Cuba; after that, during the War of Independence, sugar production suffered a lamentable decrease falling off from a million tons a year to two hundred thousand tons, while last year our production reached the astonishing amount of five million two hundred thousand tons.

During last year, this indicated amount, could have been surpassed if it had not been for the fact that Cuban producers themselves wanted, for the good of the industry, to restrict the production of that product.

If you make a tour of the Island you will see for yourselves the great amount of cane in the fields from which there could have been produced five and a half million tons.

The fertility of our soils contributes to this favorable condition because, as it is known, in Cuba the plant allows five years, consecutive cuttings, as an average, there having been cases in which cuttings have been possible during six and eight years, and even more.

The natural conditions of the climate and soil of our country make it highly propitious for the development of that plant of insular nature; not continental.

Our methods of cultivation, as you will be able to observe, are still quite deficient and, in many cases, the proper fertilizers are not used nor attention paid to the important matter of irrigation, it being a fact that "Cane is a Plant of Irrigation" as it has been said by Mr. Alvaro Reynoso, the greatest authority in the matter.

Up to the present, we have not given to the words of our wise fellow-countryman the importance that they deserve and it can nearly be said that we have not taken a step forward in the matter of irrigation. From the industrial standpoint, as you know, Cuba is on a par with the most advanced countries and in our country the center of the largest producing capacity can be found. Besides those favorable conditions of our soil, we have other advantages that permit the profitable exploitation of said cultivation. In spite of our high wages we are able to compete with other sugar producing countries, where labor obtains lower wages.

Our geographical position is another very profitable factor. In the matter of fuel, for example, it can be said that we are in the center of the largest oil producing countries of the world; we have Texas, Mexico, Venezuela and Colombia. Besides, not very far from our ports, we have the enormous market of the United States and another, also very important market, Canada, with which the volume of our business will increase daily. We maintain easy relations with England and a few days ago we had the pleasure of inaugurating telephone communications with London, thereby opening a rapid service for the exchange of orders with one of the largest centers of consumption of the World, as is England. Under these conditions it is evident that our position as a sugar producing country real-

ly rests upon a solid base. We have this year limited sugar production, because we considered that it was a measure advantageous not only to us, but in general, to the sugar interests of the World.

It would be convenient that we all act in accord and harmonize interests, following a line of action that will sustain the price of sugar on a high level which will be of benefit to the entire world, bringing about stability in the markets.

On the other hand, the possibility of improvement of our cultivation assures Cuba an ample future in the struggle.

We are, therefore, in a condition to produce a larger amount of sugar and we wish that we could reach some agreement among all those interested in this industry and work in common accord or carry on propaganda for the establishment of conditions that will allow honest competition to the benefit of the world's interests.

In the name of the Honorable President of the Republic, I open this Congress and express the wish that the work carried on and the ideas that may be exchanged here, may result in great benefit for those present, the country and the world in general.

The delegates can present their works in three languages, to wit; Spanish, English, and French, as there will be interpreters in those three tongues.

Mr. Agee then introduced to the Conference, General Jose B. Aleman, Secretary of Public Instruction for Cuba.

DISCURSO DEL GENERAL JOSE B. ALEMAN

Secretario de Instrucción Pública

Tengo la alta satisfacción, siguiendo la norma trazada por el Secretario de Estado, a nombre del Sr. Presidente de la República, de dar la bienvenida a los extranjeros que hoy nos honran con su visita y desearles que reciban los mayores beneficios de estas conferencias que ahora tan felizmente se acaban de iniciar. Por medio de la discusión se hace la luz y el intercambio de ideas contribuye a la formación de una base sólida que ha de redundar en provecho de todos los interesados. Nuestra patria es pequeña en población y área; pero es grande en aspiraciones y todos sus hijos esperan con verdadero interés que este Congreso sea el precursor de un mejor acercamiento y entendimiento entre los países productores de azúcar.

Al rogarles que acepten estas frases como una expresión sincera que sale de lo más íntimo del alma, tengo el gusto de desearles una feliz y provechosa estancia entre nosotros a todos los congresistas.

This address was also interpreted into English by Sr. Ibor.

ADDRESS OF GENERAL JOSE B. ALEMAN
SECRETARY OF PUBLIC INSTRUCTION

Gentlemen:

Following the lead of the Secretary of State in the name of the Honorable President of the Republic, I have the great pleasure of welcoming the foreigners who honor us with their presence and of wishing them that they may receive great

benefits from these conferences which have been so happily begun. Discussion brings light and the exchange of ideas contributes to the formation of a solid basis which will result in benefit for all those interested. Our country is small in population and area but large in aspirations, and all her sons trust, with genuine interest, that this Congress will be the means of bringing about better and closer relations and understanding among the sugar producing countries.

While begging you to accept these phrases as the sincere expression which emanates from the depth of my soul, I have the pleasure of wishing you, the Delegates, a happy and profitable stay among us.

The next representative of the Cuban Government being introduced by Mr. Agee was General Manuel Delgado, Secretary of Agriculture, Comerce and Labor, for Cuba.

DISCURSO DEL GENERAL MANUEL J. DELGADO

Secretario de Agricultura, Comercio y Trabajo.

Como Secretario de Agricultura, tengo el honor de dirigir la palabra nada menos que a aquellos individuos que han dedicado toda su energía a la producción azucarera.

No habiéndonos podido honrar con su presencia el Sr. Presidente de la República, ha tocado al Sr. Secretario de Estado el dar la bienvenida a los Congresistas y encargarse de la apertura de este Congreso.

Yo no tenía pensado hacer uso de la palabra esta mañana, pero hecha la indicación de que hablase el distinguido Sr. Secretario de Instrucción Pública, no podía permanecer en silencio el Representante de la Secretaría de Agricultura toda vez que los asuntos que aquí se han de discutir son de carácter eminentemente agrícola.

Esta República, esta tierra, se halla situada como por un don de la Naturaleza, en el lugar que ha de recibir la visita de representantes de los países más importantes azucareros del mundo, y donde han de discutirse problemas que han de tener gran trascendencia para Cuba y para los otros países productores de azúcar.

Nuestro gobierno, al reducir la cantidad de sacos de azúcar en la presente zafra, no ha reparado en el sacrificio que ello representaba para nuestros productores. El móvil que le ha guiado a adoptar esa medida no ha sido otro que el empeño por estabilizar el precio del artículo que ya tocaba niveles extremadamente bajos debido a la abundancia en los mercados del mundo. Esta actitud de Cuba no solo ha de reundar en beneficio propio, sino en el de los otros países también productores de azúcar a pesar de que éstos no hayan tenido que hacer sacrificio análogo, pero siendo el nuestro el principal centro de producción del azúcar del mundo ha querido tomar la iniciativa sin reparar en los sacrificios que pudieran representar y con miras únicamente a obtener un mejoramiento en los mercados de este producto.

Apelamos, pues, al espíritu de cooperación que indudablemente anima a todos los aquí presentes para que pongan lo que esté de su parte en favor de una campaña sana y práctica como la que hemos iniciado los Cubanos.

Señores, sírvanse aceptar mi más cordial saludo de bienvenida y mis augurios de una provechosa permanencia entre nosotros.

Address of General Manuel J. Delgado, Secretary of Agriculture, was interpreted into English by Sr. Ibor.

ADDRESS OF THE SECRETARY OF AGRICULTURE GENERAL MANUEL DELGADO

Gentlemen:

As Secretary of Agriculture, I have the honor of addressing those who are no less than the persons who have dedicated all their energies to sugar production.

The Honorable President of the Republic not being able to honor us with his presence, it has been the privilege of the Secretary of State to offer welcome to the Delegates and to open this Congress.

I did not intend to speak this morning, but the Secretary of Public Instruction having been requested to speak, the representative of the Department of Agriculture could not remain silent, specially as the matters to be discussed here are of an eminent agricultural character.

This Republic, this land is situated, as by a special concession of nature, in the place in which she is to receive the visit of the representatives of the most important sugar countries of the World, and where problems that will be of great importance for Cuba and the other sugar producing countries, will be discussed.

Our government in reducing the amount of sugar sacks in the present crop, has not taken into account the sacrifice that it means to our producers. The motive which has guided it in adopting this measure, has been no other than the desire to stabilize the price of the commodity, which has already reached extremely low levels due to the abundance in the markets of the world. This stand of Cuba will not only result in our own benefit, but also in that of other countries which are also sugar producers, though they may not have been obliged to make a similar sacrifice, but our country being the principal center of sugar production of the World, we wanted to take the initiative without considering the sacrifice that it represents and with the view of obtaining an improvement in the markets of that products.

We appeal, therefore, to the spirit of cooperation which no doubt inspires all those here present, in order that they do all in their power in favor of the sane and practical campaign which has been started by the Cubans.

Gentlemen, please accept my most cordial greeting of welcome and my hope of a profitable stay among us.

In addition to the representatives of the government who addressed the assembly the following officials of the Republic of Cuba were present to greet the foreign visitors.

Sr. Jose Maria Espinosa, President of the Cuban Sugar Commission.

Dr. Jose Comallonga, Director of the School of Agriculture.

Dr. Gerardo Fernandez Abreu, Rector of the University.

Reply of Mr. H. P. Agee, General Chairman of the International Society of Sugar Cane Technologists:

On behalf of the members of the International Society of Sugar Cane Technologists, I wish to thank you for your words of greeting and to express to

you our appreciation of the plans that have been made for our interest and enjoyment.

Before coming to Cuba we had learned enough of it to lead us to anticipate much, and in the short time we have been here we have been so impressed by the beauty of the Island, the charm of your capital city, and the graciousness of the Cuban people, that we feel that our stay here will be one of the most enjoyable experiences of our lives.

It is an unusual occasion when sugar cane technologists from nearly all the cane growing countries meet to confer. We will find much of interest in discussing our work, and we trust that our conferences will result in a better understanding of the issues that confront us and that they will be of aid to the technologists here and elsewhere in dealing with the problems that are before them.

I wish I had a command of Spanish that would enable me to tell you our thoughts on this occassion—and I wish I had the command of English of our able interpreter, Señor Ibor, to better fit me as spokesman in expressing our gratitude at the reception that has been given us. I can merely thank you again and assure that we sincerely appreciate all that is being done for our pleasure and to make our convention a real success.

MR. AGEE: It will be possible to hear briefly from the representatives of the various cane growing regions. I will call the names of those will be asked to say a few words and request them to take seats on the platform.

As the first speaker it gives me much pleasure to introduce Dr. G. M. Fortun who is the Chairman of the Cuban Section of the International Society of Sugar Cane Technologists for Cuba.

In addition to Dr. Fortun, the representatives of the following sugar cane regions were called upon and made brief remarks concerning the sugar industry as applied to these places:

Dr. Julius Matz for the Dominican Republic.
Dr. H. F. Clarke for Fiji.
Dr. Migaku Ishida for Japan and Formosa.
Mr. D. M. Semple for Great Britain.
Mr. W. R. McAllep for Hawaii.
Dr. Jacob Jeswiet for Java.
Mr. P. E. Long for Mexico.
Dr. Ph. van Harreveld for the Netherlands.
Dr. F. A. Lopez Dominguez for Porto Rico.
Mr. W. T. Seymour-Howe for Queensland.
Mr. H. H. Storey for South Africa.
Dr. E. W. Brandes for the United States.
Mr. D. M. Semple for the Phillipine Islands.

At this point Mr. E. L. Anderson, Secretary on Arrangements for the Havana Convention made announcements of the general plans for the Convention.

FINAL SESSION

Saturday afternoon, march 19, 1927.

Selection of Next Meeting Place and Election of Officers.

At the final session of the Conference, the Executive Committee presented to the Society for their consideration, the selection of Java as the next meeting place of the Society. On motion duly made, seconded, and carried, the Society unanimously approved the selection of Java as the next meeting place and voted that the Third Triennial Conference of the Society would be held at Pasoeroean, Java.

The following officers were nominated by the Executive Committee to serve during the next triennial period:

Dr. Jacob Jeswiet of Java, General Chairman.
Mr. D. L. Van Dine, of Cuba, General Secretary.

On motion duly made, seconded, and carried, these officers were unanimously elected to serve during the period indicated, including the Pasoeroean Conference.

The Constitution of the Society provides for the General Chairman to appoint an Assistant Secretary, to act also as Treasurer, such Assistant Secretary to be resident in the country represented by the General Chairman. In accordance with this provision, and with the approval of the Society, the newly elected General Chairman, Dr. Jeswiet, appointed as Assistant Secretary,

Dr. Victor Koningsberger, Director, Department of Agriculture, Experiment Station, Pasoeroean, Java.

MOTIONS AND RESOLUTIONS

It was voted by the Society that the report of the Assistant Secretary-Treasurer of the Society for the past triennial period, with the audit of the balance of the funds to be turned over to the newly elected General Chairman, be approved and accepted, and it was further voted that the funds remaining in the treasury be turned over to the incoming General Chairman with authority to use as he sees fit in attending to the affairs of the Society and promoting interest and attendance at the next meeting of the Society.

It was voted in the matter of dues, that dues collected from members previous to five days before the opening of the Havana Conference would apply to the period ending with the Havana Conference but that all subsequent dues collected would apply to the period ending with the Pasoeroean Conference.

It was voted by the Society that a resolution be addressed to the Japanese Experiment Station in Formosa and to the Dutch Experiment Station in Java, enlisting cooperation in the matter of translations of their publications into English to be made available to the members of the Society, for the reason that the Japanese and Dutch languages were not familiar to many members of the Society. The matter was left in the hands of the newly elected General Chairman for action in presenting the desire of the Society to these Stations.

It was voted as proper and fitting that resolutions be adopted expressing to the Cuban Government and to others, the appreciation of the Society for the reception, attention and consideration that had been extended to the members in

Cuba. Such resolutions were drafted by the newly elected General Chairman, in conference with the retiring. Chairman, and addressed to the following:

The Honorable President of Cuba.
The Honorable Secretary of State for Cuba.
The Honorable Secretary of Agriculture for Cuba.
The Cuban National Association of Sugar Cane Technologists.
The Cuba Sugar Club.
The Cuban Society of Engineers.
Sr. Dr. Jose Comallonga, Director, Escuela de Ingenieros Agronomos y Azucareros, Quinta de los Molinos, University of Havana.
Dr. Gonzalo M. Fortun, Director, Estacion Experimental, Santiago de las Vegas.
Sr. Rafael S nchez Aballi, Secretary of Communications for Cuba.
Mr. Chas. H. Thrall, Cuba Sugar Club.
Mr. E. L. Anderson, Cuba Sugar Club.
Mr. D. L. Van Dine, Cuba.
Mr. Henri Brandt, Habana.

It was voted as the desire of the Society that a Committee be appointed for the purpose of considering the greet advantage to the sugar world if Dr. Jacob Jeswiet of Java could be persuaded to publish, in book form, in the English language, his work on the botany, varieties, propagation and selection of sugar cane. It was further voted that such a Committee would be authorized to finance such an undertaking independently of the funds of the Society, if found appropriate. In accordance with the above the following Committee was appointed by the retiring General Chairman, in conference with the incoming officers:

Charles H. Thrall of Cuba. . . . . Chairman
H. P. Agee, Hawaii.
E. W. Brandes, United States.
F. A. Lopez Dominguez, Porto Rico.

It was also voted as the desire of the Society that suitable resolutions be drafted to express a deep sense of gratitude to Mr. John Bovell of Barbados for his work on sugar cane, particularly his early work on the production of canes from seedlings. In accordance with the above, Dr. E. W. Brandes of Washington, D. C., was appointed as Chairman of a Committee with authority to appoint such other members as appropriate, to carry out the wishes of the Society. This Committee offered the following resolution which was accepted by the Society for its records:

Whereas, the great importance of systematic research on the amelioration of the sugar cane plant by seedling production has been abundantly demonstrated to the sugar cane industry of the world by the remarkable performance of superior seedling varieties in many regions and

Whereas, one of the important sections of this gathering is exclusively devoted to a discussion of sugar cane breeding for the production of improved seedlings and

Whereas, Mr. John Bovell, recently retired Director of Agriculture, Barbados, Imperial Department of Agriculture for the West Indies, is one of the pioneers who, in collaboration with the Hon. Sir. J. D. Harrison, independently discovered the existence of viable sugar cane seeds and immediately began methodical produc-

tion and testing of cane seedlings thereby laying the foundation for the present important work of many of our experiment stations it is;

Resolved that the assembled delegates to the Havana meeting of the International Society of Sugar Cane Technologists express to Mr. Bovell their appreciation of his contributions toward improving the standards of sugar cane husbandry.

It was voted as the special desire of the Society that suitable resolutions be drafted to the memory of Sr. Gaston Alonso Cuadrado, who was a pioneer in sugar work in Cuba and who had looked forward with much pleasure in attending the meetings of the Havana Conference and which his recent death prevented.

In accordance with the above the following Committee was appointed by the General Chairman in conference with the outgoing officers:

G. M. Fortun, Cuba. . . . . Chairman
E. C. Coates of Louisiana.
J. R. Johnston, of the United States.
F. A. Lopez Dominguez of Porto Rico.

It was voted that letters of appreciation be sent to the government of Porto Rico and to the sugar cane interests of that country, expressing the thanks of the Society for their invitation to hold the next meeting in Porto Rico and the regrets of the Society that it will not be able to accept their hospitality, since to meet the wishes of the members is has been found necessary to alternate the Conferences between the Eastern and Western Hemispheres. Letters were drafted and sent to the following:

The Honorable Governor of Porto Rico, San Juan, Porto Rico.
Sr. R. Aboy Benitez, President, Asociacion de Productores de Azucar de Puerto Rico, San Juan, Porto Rico.

REGULAR STANDING COMMITTEES

It was voted that in order to meet the desire of the Society for a means of compiling and distributing information during the period between conferences, regular standing committees be appointed on each of the main technical subjects of the Havana Conference.

It was felt by the Society that the Chairman in each case should organize the work of these Committees and use the established Sugar Trade Journals for such material as may be appropriately published. This will avoid expense in connection with Committee work, but, should occasion require any undertakings that involve financing, the committees are to arrange for this as they see fit, but independently of the funds of the Society. The Society funds are intended for promoting attendance at conferences and miscellaneous expenses connected therewith, as the General Chairman may direct.

It is understood that the Committees will report upon their work at the next Conference. It is also understood that the Chairmen have the authority to increase the membership of these Committees to meet their requirements.

In accordance with the above, the following *Regular Standing Committees* have been appointed:

Protective Sugar Cane Quarantine: (Digest of laws, regulations and practices relating to sugar cane).

W. A. Orton, United States. . . . . Chairman
E. W. Brandes, United States.
J. R. Johnston, Cuba.
T. Miyake, Formosa.
O. H. Swezey, Hawaii.
G. Wilbrink, Java.

Insect Pests of Sugar Cane: (Including biological control).

F. Miur, Hawaii. . . . . Chairman
T. E. Holloway, Louisiana.
Dr. Hazelhoff, Java.
Dr. Masato Ishida, Formosa.
H. T. Osborn, Mexico.
D. L. Van Dine, Cuba.

Diseases of Sugar Cane:

G. Wilbrink, Java. . . . . Chairman
E. W. Brandes, United States.
C. W. Edgerton, Louisiana.
J. A. Faris, Cuba.
J. R. Johnston, Cuba.
H. Atherton Lee, Hawaii.
T. Miyake, Formosa.
J. Matz, Porto Rico.
D. S. North, New South Wales.
H. H. Storey, Natal.

Varieties: (Including propagation and selection).

W. G. Moir, Hawaii. . . . . Chairman.
B. A. Bourne, Florida.
H. F. Clarke, Fiji.
F. S. Earle, Cuba.
Jacob Jeswiet, Holland.
F. A. Lopez Dominguez, Porto Rico.
A. H. Rosenfeld, Louisiana.
T. S. Venkatraman, India.

Cultivation and Field Operations.

F. S. Earle, Cuba. . . . . Chairman
E. L. Anderson, Cuba.
G. M. Fortun, Cuba.
V. Koningsberger, Java.
F. A. Lopez Dominguez, Porto Rico.
W. G. Taggart, Louisiana.
J. A. Verret, Hawaii.

Factory Operation and Chemical Control.

P. C. Tarleton, Cuba. . . . . Chairman.
Frederick Bates, United States.
Noel Deerr, India.
Ph. van Harreveld, Holland.
Dr. Honig, Java.
W. R. McAllep, Hawaii.
P. van Du Horst, Java.
F. W. Zerban, United States.

SPECIAL STANDING COMMITTEES

It was also voted that in connection with special phases of work of interest to the Society, special standing committees be appointed on each of the subjects presented to the Society for such consideration.

The Chairman in each case will organize the work of these Special Committees and use the established Sugar Trade Journals for such material as may be appropriately published. This will eliminate expense in connection with committee work, but should occasion require any undertakings that involve financing, the committees are to arrange for this as they find convenient, but independently of the funds of this Society.

It is understood that these Special Committees will report upon their work at the next Conference. It is also understood that the Chairman has the authority to increase the membership of his committee to meet its requirements.

In accordance with the above, *Special Committees* have been appointed, as follows:

Forestry:

H. L. Lyon, Hawaii. . . . . Chairman.
W. P. Kramer, Porto Rico.
D. M. Matthews, United States.

Cooperative Exploration for Parasites of Sugar Cane Insects.

A. H. Rosenfeld, Louisiana. . . . . Chairman.
J. T. Crawley, Cuba.
Julius Matz, Porto Rico.

Uniformity in Reporting Factory Data:

F. W. Zerban, United States. . . . . Chairman
M. A. Del Valle, Porto Rico.
P. C. Tarleton, Cuba.

Soils:

C. N. Ageton, Cuba. . . . . Chairman.
R. V. Allison, Florida.
C. E. Coates, Louisiana.
W. T. McGeorge, Hawaii.
Oswald Schreiner, United States.
G. R. Stewart, Hawaii.
Mrs. C. Van Harreveld, Lako, Java.
J. H. White, Java.

PROCEEDINGS OF HAVANA CONFERENCE

SECTION I

PROTECTIVE QUARANTINE MEASURES FOR SUGAR CANE

E. W. Brandes, *Chairman.* J. R. Johnston, *Secretary.*

Methods and Measures to Prevent the Introduction of Sugar Cane Pests and Diseases.

Java.
United States.
Hawaii.
Fiji.
South Africa.
Formosa.
Cuba.

A Quarantine Greenhouse for Sugar Cane. By E. W. Brandes.

SECTION I.

PROTECTIVE QUARANTINE MEASURES FOR SUGAR CANE

March 15, 1927, A. M.

This meeting was devoted mainly to general discussions by the various delegates on methods and measures adopted in their respective countries to prevent the introduction of sugar cane pests and diseases.

JAVA

Dr. Ph. Van Harreveld stated Java has suffered from diseases which has made us very careful when introducing new canes from other countries. The principal disease which had attacked the crop in Java was the sereh disease. This disease came to our attention after 1880. However, we do not believe it entered Java but that it always existed in the country, though it was an ignored fact. Circumstances and different conditions of growth, rainfall and soil have a great deal to do with the spreading of this serious disease. We were fortunate enough to have detected this disease at a time when the prices of sugar were dropping to very low levels and it was not possible for growers at that time to make any profit. There was nothing left to do but get down to business and find some remedy which would increase the producing capacity of our fields. After some study of the conditions it developed that the cane grew better and freer from diseases in the mountains where good rainfall, good irrigation, and good drainage are found. Good drainage above all is an important item, for without it, all cane gets diseased. So the nurseries for plant cane were brought to the mountains and provided sound cuttings for the fields in the plains. We looked also for varieties which were less susceptible to the sereh disease, and as soon as we were able to discover and select varieties of more resistance to the disease, we no longer had trouble with sereh. The sereh disease is now very general in the Island of Formosa. In spite of our diligence and undying efforts with a view to stamping out all diseases, we have succeeded in

alleviating the situation to a great extent, but this does not mean that we are now free from all sugar cane diseases. Sereh is still to be found in a small number of fields of the weaker varieties. We consider this disease to be caused by a bacterium which is not entirely parasitic but which is half parasitic, and is called *Bacillus vascularum*. The plant affected by this disease dries out and makes roots where it ought not on the stalks and the plant is thus weakened and does not develop.

The leaf-scald has been in Java as far back as we can remember. It has been for many years confused with other diseases. First it was confused with Cobb's gumming disease of Australia, but Dr. Wilbrink detected the specific bacteria of the leaf scald. In order to keep away Cobb's gumming disease of Java, we had to be very careful not to bring in any diseased material. To control the leaf-scald we selected varieties which were resistant to it. There are many varieties which are resistant to leaf scald, some of them being 100 percent resistant to it.

Another fear was to import into Java the Fiji disease of sugar cane. This has spread from Fiji to other countries where Badilla cane is grown. First we heard horrible things about this disease but afterwards we found that it did not spread so rapidly as it was thought at first; in the Philippines it is kept under control by selecting healthy plant material. The weevil-borer has not become established in Java, but has been intercepted and destroyed in importd cuttings. So no disease is known in Java which was imported from elsewhere. The Government has helped us immensely in keeping away from Java all those major sugar cane diseases, by regulations which prohibit the importation of varieties from any country unless the importer of same had been duly authorized to do so through official channels. This ruling has been adhered to as far as it has been practicable to do so, and although we cannot affirm that some "bootlegging" of cane varieties is not going on in Java, it can be safely asserted that many precautions are taken to prevent introduction of undesiderable material. In Java we have collected a large number of varieties; perhaps we have the largest collection of varieties of all sugar-producing countries in the world. We are strong for the importation of healthy varieties in the broadest scale, for in so doing we feel that we are simply adding to our stock of material from which we can make selections.

Then Dr. Van Harreveld pointed out the great help which they derived from the use of fertilizers and the application of proper methods of cultivation.

UNITED STATES

The quarantine measures adopted by the United States Department of Agriculture were explained by Dr. E. W. Brandes. The discussion was prefaced by a series of lantern slide illustrations showing the principal diseases and pests affecting the sugar cane, emphasis being given to those of interest to Cuba, due to the danger of their introduction if the necessary precautions are not taken.

The following lantern slides were shown and explained by Dr. Brandes.

1. A field attacked by the mosaic disease in the Philippine Islands, practically all plants being infected.
2. An illustration of the leaf scald disease.
3. Condition of a field of D-74 cane on alluvial soils of the Mississippi River in Louisiana, suffering from the root trouble.

4. Illustrating one of the root-eating animals, which was discovered by Dr. R. D. Rands. This picture shows clearly the damage done to the seed cane by a small mollusk *(Zonitoides arboreus Say)* which eats the roots as they germinate.
5. Damage done by small centipede *(Hanseniella unguiculata)* which pits the roots.
6. Showing the well known gumming disease which is caused by *Bacterium vascularum*. This was discovered in Porto Rico recently. This disease can be more readily detected than leaf scald.
7. Fungos (?) parasites growing in cane roots.
8. The Chlorosis disease of sugar cane, which attacks the leaf itself instead of the leaf sheaths.
9. The leaf spot disease. This is not present here but may become a menace, and though of not as great an importance as the other diseases, it is worth studying.
10. An illustration of the serious disease of sugar cane called the Downy Mildew.
11. Another picture showing the Downy Mildew in the early stage.
12. The downy mildew disease, showing lenghened joints as a result of the stimulation produced by the infection, this being one of the characteristic signs of the disease.
13. Illustration of plants which were stunted in their growth by the downy mildew disease.
14. Showing the well known Fiji disease. In this picture there appears a planting which contracted the disease from one infected plant.
15. Destruction caused by (the serious) Fiji disease.
16. Another picture showing the disastrous effects of the Fiji disease.
17. Picture showing plant affected by the Fiji disease in comparison to healthy plants.
18. Showing the symptom of the Fiji disease, which is represented by galls, on the inside of the leaves. It is undoubtedly a parasite which causes this disease.
19. Picture showing the well-known mosaic disease.
20. Also the mosaic disease.
21. Picture from Philippine Islands showing plants grown from selected and unselected cuttings.
22. The mosaic disease shown on Yellow Caledonia cane in comparison with healthy stalks.
23. The leaf spot disease in the Philippines.
24. An illustration of the rust disease of sugar cane which is well known in the Orient. The picture was taken in the Philippines but the disease also occurs in Java.
25. Picture taken near Tajocu in Formosa, showing effect of the sereh disease.
26. The cane smut disease caused by *Ustilago sacchari*. This disease is present in Guiana and was reported also in Trinidad, but the latter report seems to have been erroneous.
27. An interesting picture of the effects of cane smut.
28. Picture of grass mosaic affecting corn.
29. Picture taken in 1914 or 1916 showing importance of Yellow Stripe, three years before it was reported in Porto Rico.
30. Effect of mosaic on leaves of cane in comparison with healthy leaves.

31. Picture showing the adult of the moth stalkborer.
32. Showing the eggs of borer on leaf.
33. Larva of Diatraea.
34. Appearance of the stalk affected by the disease.
35. A field showing unusual destruction by the moth stalkborer. This picture was taken by Doctor Hinds to whom we are indebted for all these slides on moth stalkborer.
36. Picture showing field affected by the moth stalkborer near Baton Rouge, Lousiana.
37. Showing streak of sugar cane in Uba cane. (Streak-disease pictures by Dr. Storey).
38. Showing the streak disease in maize.
39. Maize plant showing streak disease.
40. Same disease in maize, showing difference from mosaic.
41. The streak disease in the variety closely related to Uba.
42. Picture of leafhopper which transmits the streak disease.
43. Moving picture showing quarantine greenhouse in Washington. The precautions taken to prevent spread of infections diseases and to exclude insects from the greenhouse are particularly streessed in the picture.

HAWAII

Mr. Agee stated that in Hawaii the regulations applying to importations of cane from other countries, were even stricter than in the mainland of the United States. For a long time it had been the policy to prohibit all canes. It was not until Doctor Brandes had established his quarantine station that the planters were advised to introduce the canes into Hawaii through Washington. When importing these canes via Washington we proceed much along the same lines as they do in Washington. This means that after the strict inspection to which canes are subjected in Washington before they are released, and in spite of the fact that they are supposed to be perfectly safe and sound, we then subject the cuttings to a second quarantine the same as they do in Washington when they first import them. This is done as a factor of safety. The canes are received and examined by pathologists and entomologists. All discolored parts are removed and suitably cleaned and then placed in the quarantine house which is constructed somewhat on the same basis as that of Washington. Then Mr. Agee went to the blackboard and, for the benefit of those present, drew a diagram of their quarantine house, giving details of its construction. These canes in the house are planted in sterilized soil and this soil is sterilized by three separate heatings, and the canes are irrigated with filtered water. On one occasion in 1925 we had a development of abnormal symptoms in two varieties, a trouble we termed galls. The canes of the entire house were destroyed as a measure of precaution. We do not know that it is a disease and are studying it. I have talked with Dr. Jesweit and Dr. Van Harreveld, who are rather satisfied this is not a disease in the sense of being an infectious malady. After canes are taken out of the quarantine house we hold them again for observation during eight months to a year before sending them out to plantations. In all we have imported about 20 varieties under the quarantine as outlined.

Dr. Brandes stated that in Hawaii they were extremely careful inasmuch as they did not believe that sufficient precautions were taken in Washington.

FIJI

Mr. Clarke from Fiji, mentioned that in the past his company had introduced a number of cane varieties from New Guinea for commercial purposes and also for use as seedling parents. No leaf scald disease was discovered in them until 1921. When this was discovered we took precautions for future protection. We now have a quarantine house in Sydney, Australia, where all imported canes are placed on probation, and we expect to get our first consignment to Fiji from that house in September of this year.

SOUTH AFRICA

Mr. Storey of South Africa stated that in his country the government prohibited the importation of cane by individuals, but issued a license to the Sugar Association in special instances, in which case imported cuttings were inspected, fumigated with hydrocyanic acid gas, dipped in Bordeaux mixture, and grown in a quarantine greenhouse. Dr. Brandes asked if this gas had been found to be effective. Mr. Storey answered that he was unaware of any experimental evidence either way. Mr. Storey added that their greenhouse did not differ materially from that of Washington. Minor points were that the ventilators and overhead spray irrigation were controlled from the outside, so that the main cultural control did not necessitate the entry into the greenhouse of unskilled labor. Mr. Storey stated that into the summer air temperatures reached 110° to 115° Farenheit. Dr. Brandes agreed with Storey that high temperatures were detrimental. Cane grows very slowly.

Mr. Agee of Hawaii stated that they did not have particular trouble in that country with temperature, since they had adopted ventilation by using fine wire mesh on three sides of the quarantine houses instead of glass.

Dr. Brandes mentioned that Dr. Wilbrink of Java would be able to give an opinion on the matter of possible injury to the cane plant with the hot water treatment. The subject of injury to cane from hot water deserves study. Her experiment with hot water treatment have been in connection with treating for sereh disease.

FORMOSA

Dr. T. Miyake, Chief Quarantine Officer for Formosa, read the following paper:

How Taiwan Government Imports Cane Cuttings and Seeds

The present prosperity of the sugar industry in Taiwan is largely due to the introduction of new varieties of sugar cane from foreign countries. In the calendar year of 1926, the total area cultivated by the factories of up-to-date system was 236,000 acres, of which 95.5 per cent is planted with those varieties of foreign origin.

At the time when Japan took possession of Taiwan in 1895 the sugar canes planted there were all of native origin, with few exceptions. Following "Lahaina", which was imported for the first time from Hawaii, two varieties have been imported each year, either by Japanese Government or her private concerns.

Both in 1911 and 1912, the sugar cane suffered considerable damage by heavy storms which caused a marked shortage of crops. "Rosebamboo" proved poor against

wind, and naturally it was needed to replace "Rosebamboo" with other varieties which have more resistance against wind. As a result of those two facts, the importation of foreign varieties has been very much on the increase.

On the other hand in 1914, the Government enacted a law which is known as "imported sugar cane inspection and quarantine law" for fear bacteria, fungi, insects and the like should be introduced along with the cuttings. Under this law, the inspection is enforced of each and every cutting and seed imported. This inspection consists of two parts: one is the inspection at the port and the other is at the quarantine field.

The inspection at the importing ports.—The imported cuttings and seeds undergo a close inspection at the port through which they come. A thorough microscopical examination is made of every cutting and seed as to the presence of bacteria, fungi, etc. And thus, only the healthy ones are permitted to be imported.

Inspection at the quarantine fields.—Cuttings must stay at least two seasons in the quarantine field which is specially provided for that purpose. The field is divided into two, i. e., the primary and the secondary. The cuttings and seeds, after permitted entry, are planted first in the primary field, and those which have grown satisfactorily and sufficiently in the primary field are transplanted to the secondary field.

It is strictly prohibited to grow sugar cane within a radius of 2 or 3 miles of the field.

The inspectors make from time to time regular inspections of canes in the quarantine field during their growth, keeping a vigilant watch over the appearance of symptoms of diseases and pests, and carry out the same examination at the time of harvesting as was made when imported.

There are three Government and two private fields: One of the Government fields is a primary one and is located in the northern part of Taiwan, where the climate is comparatively moderate. Another is a secondary field which lies in the tropical zone, being in the southern part of Taiwan. The other is under direct control of the Government Sugar Experiment Station, and is called the import cane seed quarantine field. The two private fields are a primary and secondary one. Those canes which have passed the above examinations are transplanted to the ordinary cane nurseries.

Dr. Matz asked how many varieties of cane had been introduced into Formosa. Dr. Miyake replied that about 600 varieties of canes had been imported into Formosa in 15 years. Dr. Orton inquired if any diseases had been imported into Formosa. Dr. Miyake mentioned the following diseases as having been imported into that country prior to the institution of the quarantine: Red rot, pineaple disease, sereh, cane smut, and downy mildew. The last mentioned was imported into Formosa from Australia. Dr. Brandes said that this matter of quarantine is a necessary evil and that restrictions placed upon dissemination of cane varieties throughout the world became more necessary on account of the increased demand for exchange of varieties.

Dr. Faris brought out the point that many people in Cuba had gone to the trouble of importing canes from other countries without first inquiring if those same varieties were not obtainable at home. As a matter of fact he knew of several cases where introductions had been made of varieties which were readily available

in the Island. He suggested that the fact that we have varieties now available in Cuba be brought to the attention of every one connected with the sugar industry who is likely to be interested in obtaining varieties.

CUBA

Dr. Fortun, Director of the Estacion Experimental Agronomica at Santiago de las Vegas, stated that until some time ago they did not have any regulations covering the importations of canes from other countries, but that now no cane could be introduced into the Island without first being inspected and planted at the Government Station at Santiago de las Vegas, and from there distributed later on.

A QUARANTINE GREENHOUSE FOR SUGAR CANE

by

E. W. Brandes.

A brief description of the construction and operation of the quarantine greenhouse you have just seen in motion pictures may be of interest. This greenhouse is located at Arlington Farm, just across the Potomac River from Washington and represents our latest attempt to design an effective and yet simple quarantine station for sugar cane in temperate regions. The station was originally intended to provide a safe means for importing cane varieties for our own field stations in the cane regions of the South, but in recent years it has become a clearing house for cane varieties designed for experiment stations the world over. Space in the greenhouse is limited, but where the circumstances appear to warrant it we make a special effort to secure cane varieties and grow them in quarantine for any accredited institution, supplying cuttings later if the plants appear to be free from infectious diseases, or insect pests.

Two main requirements kept in mind in planning this greenhouse are prevention of spread of communicable diseases that might be introduced with shipments of cane and exclusion of indigenous insects such as native greenhouse pests and other indigenous insects that are known to act as vectors of mosaic and allied diseases of sugar cane. Insects brought in on cane cuttings from foreign countries are effectively dealt with by means of the hot water bath which will later be described.

In general, the greenhouse consists of a standard superstructure built on a reinforced concrete foundation. It is divided into equal units separated by a tight glass partition wall, the first having a well drained cement floor and the second consisting of a bed designed so that the soil of the entire bed can be steamed and disinfected in one operation. The foundation of the second unit is, practically speaking, a reinforced concrete barge sunk 3½ feet in the ground and filled with good soil to the ground level. Drainage through the concrete "sub-floor" is provided by nine screened holes in the floor and lines of four inch tiles both above and below the floor. At a depth of 24 inches below the surface of the bed or 18 inches above the floor is a series of drainage tiles laid loosely in lines two feet apart, connected at one end with the high pressure steam heating system and supplied with vents at the other end for the escape of any surplus of steam that may not be condensed in passing through the tiles. In "Sterilizing" the soil it is first drenched with formalin, then covered with heavy tar paper and the steam turned into the

buried tiles. About 24 hours of steaming suffices to kill all forms of life that we wish to eliminate. In the first unit the soil is in galvanized iron cans only and before being taken to the greenhouse is treated in sacks containing about 100 pounds each by exposure to steam under 20 pounds pressure for 6 hours in a large autoclave.

The greenhouse is 11 feet high at the eaves and twenty-one feet at ridge (fig. 7) permitting ample development of the plants. There is a covered oil moat attached to the outside of the foundation wall (fig. 8) to prevent ants and other crawling insects from climbing up the wall. A screened vestibule (figs. 8 and 9) supported on two-inch pipe standards provided with covered oil cups stands in front of the main entrance. On entering the greenhouse it is required to disinfect shoes in cresol (fig. 9) and to don a long white duster which hangs in the vestibule.

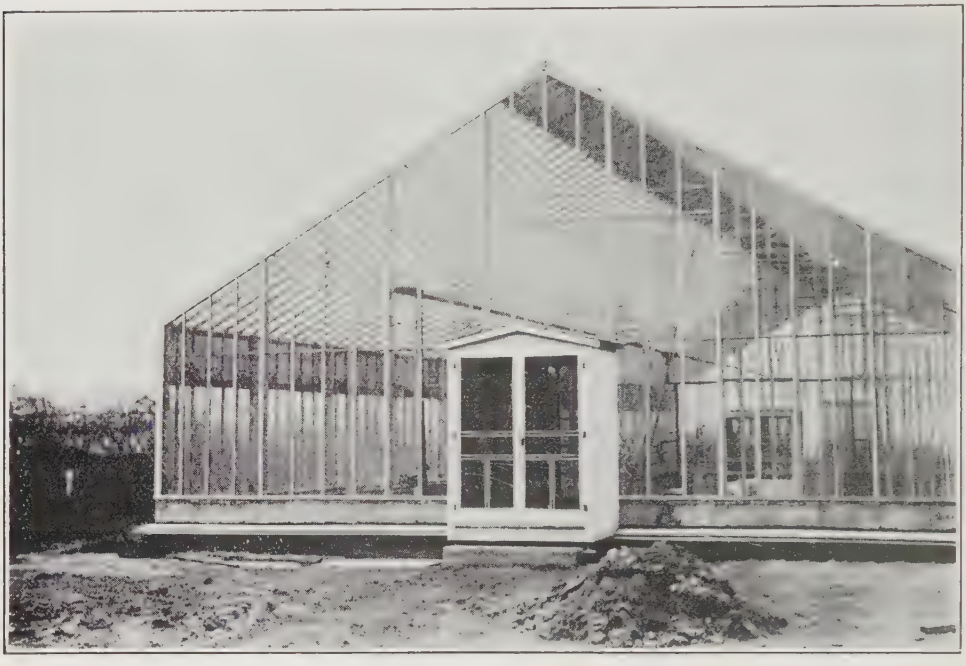


FIG. 7

Sugar Cane Quarantine Greenhouse, Arlington Farm, Va.—General view of quarantine greenhouse No. 2, showing insect-proof vestibules.

These precautions are taken to reduce the chance of taking insects or insect eggs into the quarantine house on shoes or clothing. The greenhouse is fumigated regularly with "nico-fume" as an added precaution. A vestibule separates the first and second units (fig. 12) and the same shoe disinfection is required in passing from unit No. 1 where the newly imported cuttings are planted in cans (fig. 10) to unit No. 2 where the permanent variety collection is maintained (fig. 13). The side ventilators (fig. 15) and ridge ventilators (fig. 14) are screened with copper wire cloth, 40 meshes to the inch, tacked securely to the frames from the inside. The ventilator arms, or rods, that raise and lower the sash are encased in loosely fitting sleeves, one end of which is secured to the screen and the other tied to the ventilator arm near the joint. This device, which is illustrated in figures 14 and 15, permits free movement of the ventilator arm through the screen without allow-

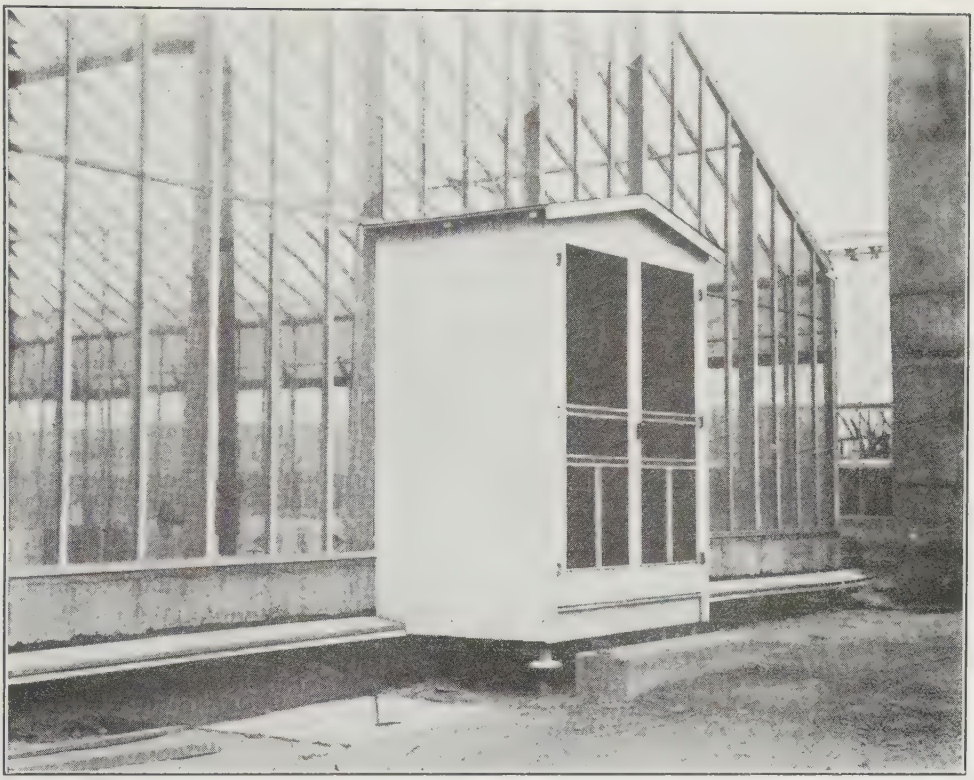


FIG. 8

Sugar Cane Quarantine Greenhouse, Arlington Farm, Va.—Outside view of insect-proof vestibule supported on 2" pipe standards equipped with covered oil cups. The concrete step with foot scraper is separated from the vestibule by an air space, and the operator when entering steps immediately into a shallow trough of disinfectant, and dons a long white coat. Note the covered oil moat that forms a part of the foundation wall of the greenhouse.

ing the entrance of insects. This completes the description of essential features of the quarantine greenhouse now in use. It is readily seen that the greenhouse is relatively simple. The greenhouse (fig. 16) which was used prior to the completion of the new one was in some ways more complicated but less effective in controlling insects. The separate compartments for individual shipments or accessions of varieties (fig. 17) in the old quarantine house have been dispensed with as unnecessary.

Establishing a new cane variety in the quarantine greenhouse begins with mailing explicit instructions regarding selections, treatment, and packing of the cutting with the request for the variety. Whenever possible the cuttings are inspected by entomologists and plant pathologists at the shipping end. When the material is likely to be on the road for a considerable length of time, one month or more, we ship a standard container to be used in packing the cuttings. This is a haevy galvanized iron box 4 x 4 x 16 inches with a cap cover at one end. It is sent filled with powdered charcoal containing 10 per cent of moisture by weight. When the package arrives it is examined by the inspectors of the Federal Horticultural Board. The modus operandi of our routine treatment is to carefully clean every vestige of leaf sheath from around the nodes to expose the eyes, and to trim the ends. If

there is no evidence of disease, the cane is then immersed in water for 20 minutes at 50.5° C. This kills all forms of insects with which we are familiar, including eggs and other dormant forms. The cuttings are then placed in 1-1000 $HgCl_2$ for 10 minutes after being dipped in 95 per cent alcohol. They are then rinsed in tap water and planted in cans in unit No. 1. If no signs of disease appear up to the time the plant attains a height of 8 to 12 feet, cuttings are taken and treated in exactly the same manner as the original cuttings, and these are planted directly in the bed in unit No. 2. If any plant in the cans in unit No. 1 appears abnormal or exhibits symptoms of disease, it it immediately placed in an isolation cage in another greenhouse (fig. 11) for observation. Among the determined diseases intercepted in this way are mosaic and leaf scald.

If the new variety continues to grow normally in unit No. 2, cuttings from this second generation stool are taken from mature stalks and shipped to field stations in the South after being given the hot water bath and superficial sterilization, as previously described. Of course, no guarantee is given that varieties when finally released are disease and insect free, but it is believed that this method of handling gives practical assurance of healthy material for shipment to commercial cane-growing regions. The method appears to be simple, but it requires eternal vigilance to see that employees rigidly adhere to the rules of conduct prescribed for them in caring for the plant, and that all others are effectively locked out.

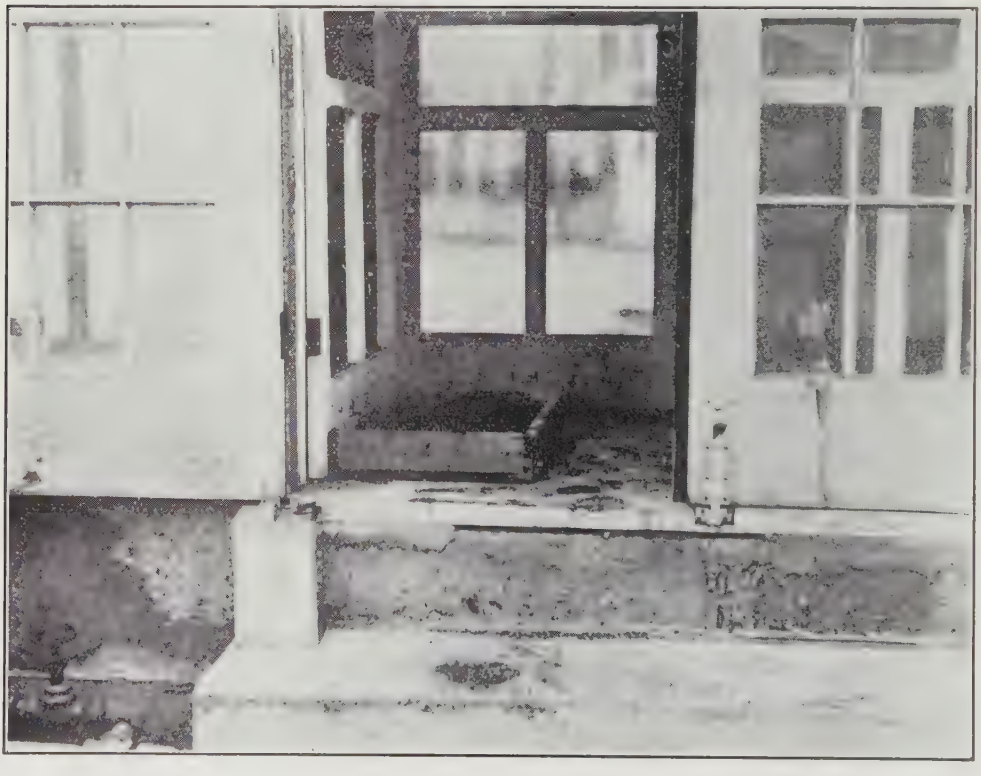


FIG. 9

Sugar Cane Quarantine Greenhouse, Arlington Farm, Va. — Insect-proof vestibule from inside of greenhouse, showing trough with fiber mat soaked in cresol for disinfecting shoes.

FIG. 10

Sugar Cane Quarantine Greenhouse, Arlington Farm, Va.—Compartment for receiving newly arrived cane cuttings, which are treated and planted in cans of disinfected soil, where they are grown until mature stalks develop.

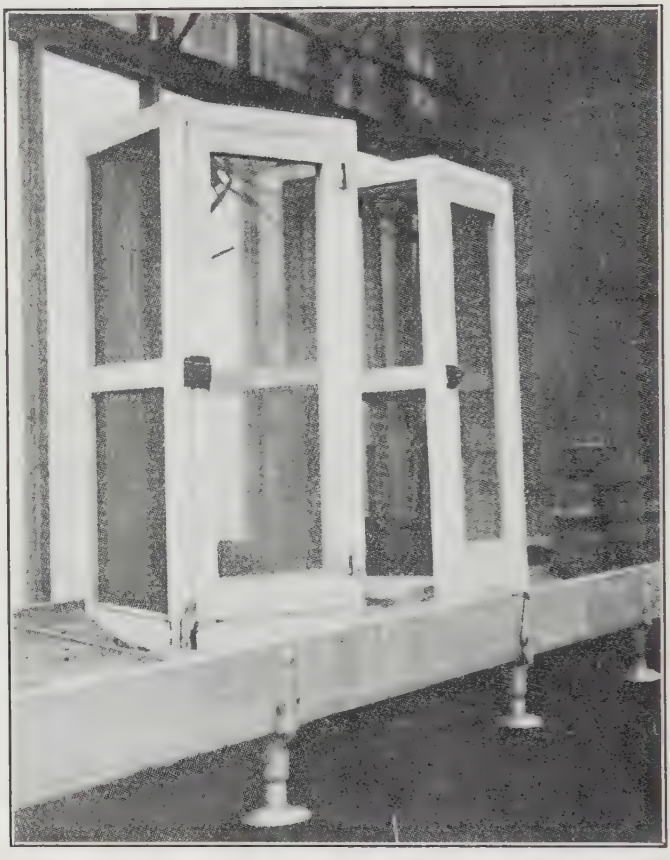


FIG. 11

Sugar Cane Quarantine Greenhouse, Arlington Farm, Va.—Portable observation cages resting on benches with covered oil cups on supports. Young cane plants with suspicious symptoms are isolated in these cages, and are later destroyed if found to be diseased.

FIG. 12

Sugar Cane Quarantine Greenhouse, Arlington Farm, Va. — Insect-proof vestibule between sections of greenhouse, and trough with fiber mat soaked in cresol, for disinfecting shoes.

FIG. 13

Sugar Cane Quarantine Greenhouse, Arlington Farm, Va.—Section of greenhouse in which are planted varieties that successfully pass preliminary observation period. This section is designed so that the soil can be completely sterilized with steam. Cuttings from these "second generation" plants are released and sent to field stations if no signs of disease appear.

FIG. 14

Sugar Cane Quarantine Greenhouse, Arlington Farm, Va.—Ridge ventilator equipped with 40-mesh copper wirecloth screen and sleeve devise for permitting free movement of ventilator arms.

FIG. 15

Sugar Cane Quarantine Greenhouse, Arlington Farm, Va. — Devise for permitting free movement of ventilator arms thru the 40-mesh copper wirecloth screens that cover all side and ridge ventilators. It consists of sleeves that fold roughly similar to an accordion bellows.

FIG. 16

Sugar Cane Quarantine Greenhouse, Arlington Farm, Va.—General view of quarantine greenhouse No. 1 and Laboratory.

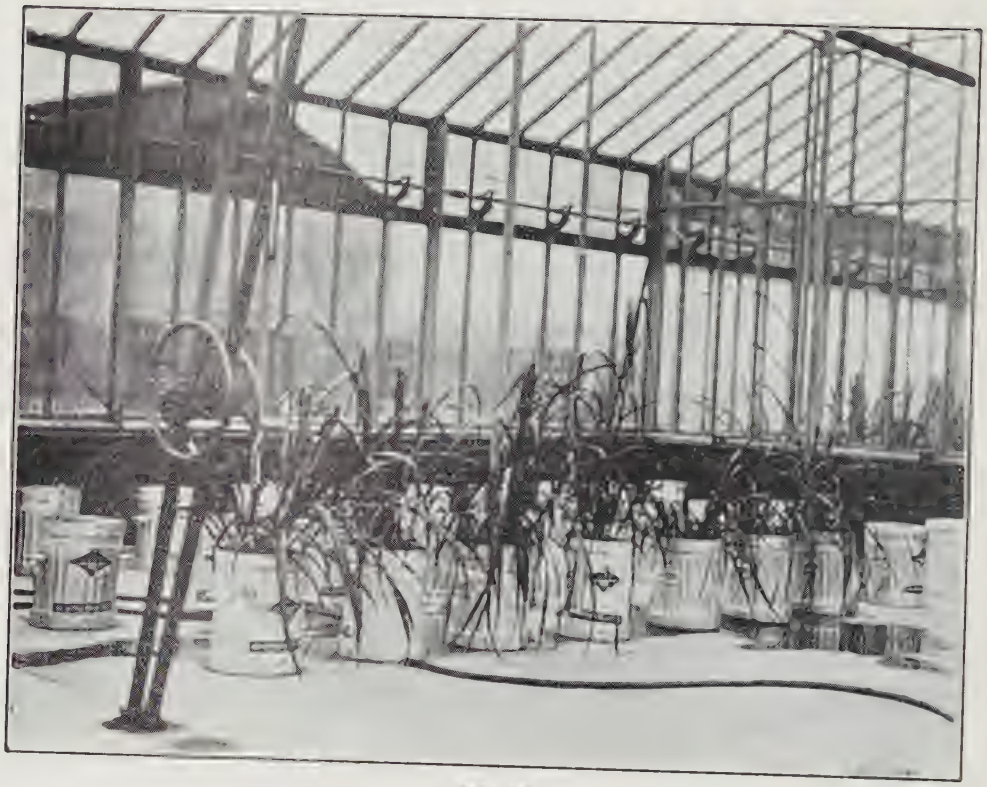


FIG. 17

Sugar cane quarantine greenhouse, Arlington Farm, Va.—Part of series of 9′×12′ insect-proof compartments in quarantine greenhouse No. 1

PROCEEDINGS OF HAVANA CONFERENCE

SECTION II.

Insect Pests of Sugar Cane (Including Utilization of Parasites).

D. L. Van Dine, *Chairman.* H. T. Osborn, *Secretary.*

Sugar Cane Stalkborers—a Discussion.
Cutting out "Dead Hearts" for Control. *By H. K. Plank.*
Control of Stalkborer by Dusting. *By W. E. Hinds.*
Airplane Dusting for Insect Control. (Illustrated by motion picture). *By C. E. Woolman.*
Corn as a Trap-Crop for Stalkborer Control. *By W. E. Hinds.*
Parasites of the Stalkborer in Louisiana. *By T. E. Holloway.*
Cuban Parasites of the Stalkborer. *By H. K. Plank.*
Losses from the Moth Stalkborer. *By J. T. Crawley.*
Grass Hosts of the Moth Stalkborer. *By H. K. Plank.*
Control of Sugar Cane Insects by Parasites in Hawaii. *By H. P. Agee.*
Parasite Exploration Work for Hawaii. *By O. H. Swezey.*
Cooperative Explorational Work for Parasites. (Presented by A. H. Rosenfeld). *By H. E. Box.*
Parasite Introductions into Formosa. *By Migaku Ishida.*

SECTION II.

Insect Pests of Sugar Cane (Including Utilization of Parasites)

A preliminary meeting of the Committee for the Section on Insect Pests of Sugar Cane was held on the afternoon of March 14th. The discussions at this meeting developed that there was a great deal of interest in the subject of stalkborers of sugar cane. It was agreed to make the subject of stalkborers the main topic at the general session for the following day, including the general subject of the utilization of parasites in the control of sugar cane insect pests. It was also agreed that the subject of the insect transmission of the mosaic disease be referred to the Section on Sugar Cane Diseases for discussion in connection with the disease mosaic and, further, that the question of such soil animals as snails, centipedes and nematodes be left to the Section on Diseases in connection with root disease conditions.

General Session, March 15th, 2:00 P. M.

The subject of stalkborers of sugar cane was opened by Mr. T. E. Holloway of Louisiana. Mr. Holloway said:

Those of you who saw the pictures this morning will realize the immense loss due to a larva boring thru the stalks of sugar cane. In cooperation with the Bureau of Agricultural Economics, we of the Bureau of Entomology have calculated an average loss in Louisiana of 19 or 20% of the full crop with an occasional loss of 30%.

Proceeding to seasonal history, the moth borer (Diatraea Saccharalis Fabr.) hibernates in planted seed cane, in sugar cane stubble to some extent and in large grasses: It also hibernates in rice stubble. Old corn stalks have been found free of hibernating borers as corn is ordinarily grown on Louisiana sugar plantations, that is, the corn being planted fairly early and drying out by midsummer and be-

coming unattractive as a food plant. The moths emerge from their hibernating places about the last of April, ordinarily. With the deposition of eggs on young cane plants the first generation commences. The young plants are completely killed, but as the cane becomes larger the work of the borer does not kill the plants. There are from four to five generations during the year, the time of a generation varying from about 45 days to a much longer period depending on the temperature.

Going on to artificial control, I might say that while Hawaii is ideally situated for parasite introduction, or biologic control, conditions in Louisiana are excellent for artificial control. We believe that by eliminating heavy grasses, by cutting the cane with a machine of some kind so as to avoid leaving tall stubble in which the larvae hibernate, and by treating the seed cane to destroy the hibernating borers, that is, by following these measures the borer in Louisiana could be controlled.

There are two treatments of seed cane—with hot water and with water of ordinary temperature. Seed cane can be treated with cold water or water of ordinary temperature—soaking the cane for seventy-two hours—and all the borers in the cane will be killed, while the germination will be stimulated. There is no doubt that this is an effective measure. A plantation which was flooded for some time, due to high water, was found afterwards to have very few borers. In the same way, the badly drained portions of a plantation are less infested than the well drained portions.

A Louisiana planter treated the seed for a portion of his plantation some years ago, and found that due to the increased germination, the work really cost him nothing at all. However, the treated cane was planted in the midst of untreated fileds, and the year was one in which practically every stalk of cane in Lousiana was bored. No evidence of benefit was observed in regard to the infestation.

We are now making an arrangement with a Louisiana sugar planter to reimburse him for the entire cost of treating all his seed cane. It is hoped that in this way definite results can be obtained on the efficiency and cost of the method on a plantation scale. Quite a long time ago the egg parasite, *Trichogramma minutum,* was found on Louisiana plantations. It occurred to me that we might try to preserve this parasite, and my idea was not to burn the leaves and tops—the "trash"—left on the fields after cutting. Mr. W. G. Taggart, of the Louisiana Experiment Station, worked out a method of cultivating the soil so that this vegetable matter would become part of the soil.

We have found a reduction in borer infestation of 50% and the soil is benefited.

To close these introductory remarks, I want to point out the various factors which influence borer abundance; Mr. W. E. Haley and myself, in "Facts about Sugar" for January 8, 1927, listed fifteen of these factors. (Mr. Holloway draws sketch on blacks board).

The "front" of a Louisiana plantation is on a water course, and here is the well drained land. The plantation runs back to a swamp, and the closer one gets to the swamp, the poorer is the drainage. The front of a plantation is always more heavily infested than the back, where the borer is drowned out—as it could be everywhere by the water treatment.

A person of little experience can easily make a mistake in conducting experiments on the borer. If you take two cottom fields and plant them with good seed you can obtain two comparable fields. But not so with sugar cane. You plant the stalks of the cane, and in planting the seed cane cuttings you are also planting borers. Under Louisiana conditions—not tropical ones—the whole effect of the early cultivation is to provide for the emergence of the moths from the seed cane. The soil

is partly removed so that the warmth of the sum will reach the planted stalks, and the soil is pulverized. If you plant cane containing live borers, you "seed" the plantations with borers as well as with cane.

Even if you plant two fields with cane having a borer infestation of 20% you cannot tell whether your fields are comparable. In one field many of the stalks may contain borers while in the other many of the borers may have left the stalk before planting.

The situation of a field on the plantation, its surroundings, whether it is a plant cane field or a stubble cane field—all these and many more factors influence the subsequent infestation.

It is, therefore, as I said, easy to make a mistake in control experiments.

Mr. Chairman, I believe that these remarks will be sufficient to open the discussion.

At the conclusion of Mr. Holloway's remarks, the Chairman called upon various men of different countries for remarks on the stalkborers.

Dr. Jeswiet from Java mentioned a borer of importance there *(Diatrea striatalis)*. He said that it was formerly a practice to cut out dead hearts as a control measure, also to collect eggs and hatch out the parasites for return to the field. This has been discontinued as a field practice, but is being tried experimentally again.

Dr. Van Harreveld of Java stated that large sums of money had been spent in the past in artificial control of borers in Java but that no practical results has been observed. In his opinion the best practice is maximum agricultural production, particularly with varieties producing a large number of shoots. He stated also that there is a natural weeding out of shoots from about 70,000 down to 25,000 per acre and that the destruction of many shoots by the borer does not affect the final yield.

In answer to a question by Mr. Matz of Porto Rico, Dr. Van Harreveld stated that the percentage of infestation ran from 20 to 100% of the stalks, that a minimum of 20% was always present. Mr. Matz also raised the question regarding the losses in the mature cane at the harvest time as distinguished from losses of shoots before they mature.

Mr. Rosenfeld of Louisiana, speaking from experience in Tucuman, questioned whether Dr. Van Rarreveld's statement would apply in a locality with a short growing season. In Tucuman the older shoots are attacked by borer, leaving the later developed shoots to produce the crop, thus shortening an already short period for the growth of the cane.

The question was brought up by Mr. Lopez Dominguez of Porto Rico as to the effect of deep planting on borer infestation.

Mr. Menendez Ramos stated that from his observations deep planting was a solution of the borer problem in the tropics.

Mr. Earle brought out the fact that in Cuba the question of clean seed (emphasized as one of the most important control measures in Louisiana by Mr. Holloway) is of minor importance since in some localities in Cuba a planting may last for twentw years. Dr. Hinds asked as to the amount of seed necessary to give a perfect stand in Louisiana. Mr. Taggert answered: four tons on the average.

Mr. Agee of Hawaii mentioned the weevil borer (*Rhabdocnemis obscurus*) problem in Hawaii, and stated that the discussion of parasites would be deferred to a later time. Dr. Storey from Natal, South Africa, mentioned a stalkborer in maize that does not attack cane.

Mr. Clarke from Fiji stated that the weevil borer, *(Rhabdocnemis obscurasu* Boisd) is a very serious pest but has been reduced in late years from an infestation of 30% in 1911 to 6% at present, due probably to various factors working together. These factors include a change of varieties, the burning of the cane before cutting and the introduction of the tachinid fly parasite from Hawaii.

Resistance of varieties to injury

Mr. Rosenfeld called attention to the conditions in Louisiana and the Argentine —the new POJ and Uba canes in Louisiana appear much more severely attacked than the old canes.

In the Argentina (Tucuman) when first spread out in small plots, the varieties POJ 213 and 36 showed very heavy infestation from borer. This lasted for a couple of years. Later, in 1919, when these varieties had been widely planted, the borer ceased to exist as a problem. Last year for the first time the borer again did some damage to the POJ canes. (This information is contained in a discussion by Mr. Rosenfeld and Dr. Cross appearing in the Louisiana Planter in recent years).

Mr. Clarke from Fiji stated that weevil borer practically wiped out some seedling canes. Mr. Holloway questioned Mr. Rosenfeld—Is the reduction in borer in the POJ canes due to the fact that they ratoon longer and that, therefore, there is less plant cane? Mr. Rosenfeld states that he did not believe that there had yet been time enough for this to be a factor.

Mr. Howe of Australia stated that the weevil borer was less abundant now than in previous years, but the reasons for this are not known.

Dr. Jeswiet mentioned the different habit of the noble varieties of cane as against the Java varieties as a possible explanation of the difference in resistance to borer. The Java cane with a stronger root system and stooling habit have the leaves pressed together at the spindle so that the larvae, hatching from the eggs laid on the leaves, are not able to get down into the stalk, perhaps.

Dr. Hinds:

Apparently the borer has different habits in different countries. In Louisiana the variety POJ 234 has been very heavily attacked by borer but on the strength of Mr. Rosenfeld's experience it is being extended. There would seem to be some inconsistency in the reports from various countries. In Louisiana there appears to be a tendency of the adult moth to seek out the densest, greenest canes for shelter while Dr. Jeswiet tells us that the drier parched areas are more heavily infested.

Mr. Barreto of Cuba remarked that the abundance of borer in different parts of Cuba is variable. He had found an infestation of less than 15% of the stalks in general but that it is sometimes higher in localities where there are large areas of new plantings. He advises deep planting as the remedy.

Seasonal and Geographical Abundance

The abundance and injury by the borer appears to vary widely under different climatic conditions and in different seasons in the same locality.

Mr. Holloway said that in Louisiana he had previously considered that the amount of rainfall had no relationship to borer abundance, but that Mr. McDonald of the U. S. Weather Service had correlated the amount of rainfall during the winter months with infestation the following Summer. After heavy winter rains there are fewer borers the following Sumer. (The Planter and Sugar Manufacturer, May 29-July 17, 1926).

Mr. Matz of Porto Rico called attention to a definite relation between droughts and very heavy infestation. Mr. Wolcott has found in Porto Rico that the borer infestation is inversely proportional to the amount of rain.

Dr. Hinds states that in Louisiana during January, February and March, 1926, there were 30 inches of rain which has been followed by an unusually light infestation during the summer of 1926. He also considered that in the summer of 1924 the length of life of the adults was affected by prolonged hot dry weather.

Dr. Jeswiet stated that in Java there is much less injury from borer in the western part where there is a more even distribution of the rainfall.

Mr. Osborn of Mexico reported that in the southern tropical section of Mexico the borer *Diatraea saccharalis,* does not appear to be a very serious problem. In most of these districts heavy rains occur during the summer months. In the state of Sinaloa on the west coast cane is grown only under irrigation, the rainfall being uncertain. There is a distinct winter season during which the cane makes slow growth. The injury from borer appears to be much more severe here than in the tropical sections, but there has been a very wide variation in abundance of infestation in different fields. In this locality a small borer, *Chilo loftini,* has for several years been of at least equal importance with the larger borer which here is *Diatraea lineotella.*

Host Plants other than Cane.

Mr. Holloway mentioned corn, sorghum, broom corn, Johnson grass and others.

Mr. Plank presented a paper on this subject as found in Cuba.

Dr. Hinds mentioned rice as a host plant.

Control Measures.—Plantation Practices.

Corn as a trap crop was discussed in a paper by Dr. Hinds.

Mr. Earle suggested that we feed black strap molasses and cut out the corn, to which Dr. Hinds replied to grow soy beans.

Mr. Holloway called attention to cases in Louisiana of the benefit of non-burning of the cane trash as an aid to the parasites and hence as a help in the control of borer.

Mr. Taggart explained that he had found it practicable to completely rot trash before spring if it was turned under and only partially covered with dirt. He did not believe that this would be practicable in the tropics, however.

Mr. Holloway requested that two of the visiting Louisiana sugar plantation men, Mr. Kemper and Mr. Munson, be asked for their opinion as to the practicability of the control measures advocated by the Department of Agriculture and the Louisiana Experiment Station, for the sugar cane borer in Louisiana.

Mr. Kemper stated that they were very anxious to make use of the recommendations, but that the system used on large plantations was largely forced upon them by conditions, that the turning under of trash might be done on a small area, but since every available source of labor is needed for other work at the time when trash should be turned under, it is next to impossible to do the work. Also the Louisiana planters urgently desire a substitute crop for corn but until a satisfactory substitute is found, they are under the necessity of growing corn for feed.

Mr. Earle said that there is no necessity for growing corn for mules as molasses is an excellent substitute.

Direct Measures for the Control of Borer.

Dead heart removal was discussed by Mr. Plank and dusting by Dr. Hinds and a more detailed discussion of dusting by airplane in a paper by Mr. Woolman. These papers follow.

Parasites

Mr. Agee gave an account of the work of the Hawaiian Sugar Planters Association in the introduction of parasites for three major pests of cane in Hawaii: the leaf hopper, cane borer, and Anomala beetle. This is presented in a paper which follows.

Discussion of this subject was participated in by Dr. Hinds, Mr. Plank, Doctor Orton, Mr. Holloway and Mr. Rosenfeld.

Mr. Rosenfeld presented a paper by Mr. Harold E. Box on a plan for cooperative international organization for parasite exploration work.

Mr. Crawley submitted a paper on the losses due to the moth stalkborer in Cuba.

Cutting out Dead Hearts in Moth Stalkborer Control.

By H. K. Plank.

When the small borers start to feed on the new cane shoots, or ratoons, they soon reach the tender growing bud inside of the stalk near the base. Their feeding in this location soon results in the killing of the central whorl of leaves, or "heart". Hence the term "dead hearts" clearly describes this early infestation of the young stalks. If one of these dead hearts be cut low enough and soon enough after being killed by the borer, it will usually be found to contain one or more borers in various stages of development.

On many badly infested plantations in some of the British Islands of the West Indies, particularly where labor is cheap and plentiful, the removal and destruction of these young infested stalks has been practiced extensively as a measure of checking or reducing the infestation of the cane by the first broods of borers and thus to decrease the number of borers to propagate and infest the cane later on in the season. The main precautions have been to remove all the dead hearts before the first brood of borers have changed to the adult, or moth, and left the young stalks, and to cut the infested shoots low enough so that the borer or borers near the base will not be left in the stubble. This operation is then repeated once or twice at an interval of about a month, or when an examination of the cane shows that the majority of the borers are about to change to moths.

It appeared desirable to test the practicability of removing these dead hearts under Cuban plantation conditions. Two caballerias, about 66--2/3 acres, of heavily infested first ratoon cane were selected for this work. Two cuttings were made. The first was made May 1--16, 1926, when the cane was about 6 weeks old, and only a small percentage of the borers had emerged as moths; this cost $67.74 per caballería. The second cutting was made about six weeks later and cost $81.90 per caballeria. No more cuttings were made as the cane was then growing at a rapid rate and many of the stalks were large enough to harbor borers in the inter-nodes and thus not show the dead heart symptom. The total cost of the two cuttings was $149.64 per caballeria, exclusive of the cost of the immediate supervision.

Frequent examinations before and after cutting showed that it was quite impossible with the labor then available for this work to get all the infested stalks cut low enough to take the borers out with them. Then, too, on account of the interference with other and more urgent work on the colonia at that time, the second cutting could not be made soon enough after the first, and all the dead hearts removed from the fields could not be promptly taken out of the guardarrayas where they were deposited in sacks and open piles by the laborers. Thus some of the effect accomplished by the first cutting was apparently lost. However, while the average number of total stalks per cepa increased at practically the same rate throughout the season in the treated fields as in the adjacent untreated ones used as checks, and the average number of infested stalks per cepa was greater in the former than in the latter at the beginning of the experiment, after the second cutting this condition of relative infestation was reversed; so that the average number of infested stalks per cepa and the per cent of stalks infested in the fields from which the dead hearts were removed never increased again much higher than to one-half the number in the untreated fields. About the same is true when the two plats are compared on the basis of per cent of total joints infested by the borer; a status examination made in January, shortly before the cane was harvested, revealed only 6.09% of the total joints infested in the treated fields, as against 11.98% in the untreated checks. It can be said, therefore, that the two cuttings reduced the infestation about 50%.

There is an important fact brought to light by the field examinations of cane in connection with this experiment which should not be lost sight of. This is reduction in the number of parasites by removing them from the field with the borers in the dead hearts. While the total parasitism of the borer was 4.9% before the dead hearts were removed, and it obviously fell after each cutting, it was not until several months after the last cutting that it rose again, and by the time the last examination was made in January it was only about 11%. On the other hand in the untreated checks it continued high from the beginning, and in January it was about 14%. This reduction in parasitism could have been very largely prevented, however, and the infestation in the treated fields perhaps been still lowered, by making some provision, such as some trap cage arrangement, whereby the parasites could have been recovered and returned to the fields.

Report on

Dusting for the Sugar Cane Moth Borer Control in Louisiana.

Presented by *Dr. W. E. Hinds.*

(The above paper is included in a more detailed report by Dr. Hinds under the title "Insecticidal Control for Sugar Cane Borers" and published as Bulletin No. 201, Louisiana State Agricultural Experiment Station, Baton Rouge, La., August, 1927).

Dusting Crops by Airplane for Control of Insects.

Presented by *C. E. Woolman*

(Illustrated by motion picture)

In discussing the use of airplanes for the distrbution of insecticides and fungicides it might be well to mention a few points in the history of the development of this unique use for airplanes.

The first dusting with airplanes was done at McCook Field in 1921 when an attempt was made to control the catalpa sphinx on a grove of catalpas near that place. The machine delegated to this experiment was an obsolete type of Army ship which was equipped with a temporary hopper attached to the side of the fuselage and which interfered with the manipulation of the machine and produced a very inferior cloud. I might say, however, that the operation was a success, although the patient died. It did, however, give birth to a new idea and, in 1922, Dr. B. R. Coad, in charge of the Delta Laboratory at Tallulah, Louisiana, began the use of airplanes for cotton boll weevil control. Army planes were loaned for the purpose and hoppers installed within the fuselage, so as not to interfere with the slipstream or air currents, and a venturi was developed that gave a fair dust cloud.

During 1923 a thousand acres were dusted by airplane with an increased yield of nearly half a bale per acre over the checked plots not dusted. The operation was found to be efficient and practicable. The cost records showed it to be economic and the method to have numerous advantages over the use of any ground equipment. The machines, however, were quite unsatisfactory and an appeal was made to commercial manufacturers of planes with the result that the Huff Daland Airplanes, Inc., now the Keystone Aircraft Corporation, developed during that year a machine specially built for this type of service, carrying its load at the center of gravity of the plane and so constructed that it could be flown and operated by one man. I might say that the idea in developing these planes was that they would be sold for dusting purposes to large plantations and to groups of farmers; however, this was found to be impractical because of the necessary reserve equipment required in the operation of airplanes and the need of a mobile reserve to meet a peak load during the season's operation.

During 1924 commercial dusting was started on a small scale and in 1925 dusting was begun in five states in the cotton belt and has since been extended, now taking in most of the southern states from North Carolina to California, with other operations in Mexico and in Peru, S. A. where a fleet of planes are now operating in the cotton valleys south of Lima.

The rapid growth in the use of the airplane for the distribution of insecticides and fungicides is due almost entirely to the advantages which this means of dusting offers the planter; namely, the speed, which varies from two hundred to five hundred acres per hour depending upon local conditions, size of field, distance from landing field, etc.; the advantage of a greater adherence of poison to the plants; the ability to dust the plants regardless of ground conditions or matted condition of the plants in the row during the latter part of their growing perior; and the fact that it obviates the need for a considerable amount of capital invested in equipment as this operation is carried on without disrupting the farm practices or makng additional demands on the farm supply of labor. Another factor which has contributed to its success is the fact that the dusting is taken out of the hands of ignorant plantation labor and is done by a highly trained specialist and that all dusting is done under the supervision of a trained entomologist as an entomologist is attached to each dusting unit, a dusting unit normally being composed of five thousand or more acres within an approximate radius of ten to fifteen miles of a central point. The work of the entomologist has been one of the largest contributing factors for, as consulting entomologists know, the average farmer has but a hazy idea as to life

histories and habits of insects and little appreciation regarding the importance of timeliness in making applications.

Airplane operations have been successfully conducted on many crops and with a great variety of insecticides and fungicides and new uses in this field are constantly appearing. The greatest use has been in dusting cotton with calcium arsenate for boll weevil control, for leaf worm control, with sulphur for cotton flea hopper, with nicotine dust for cotton aphis, and a combined calcium arsenate and nicotine dust for weevil and aphis control. Some three hundred thousand peach trees have been dusted in the Georgia peach district, dusting for curculio and brown rot control. An interesting observation was that brought out by Dr. Oliver I. Snapp of the U. S. Department of Agriculture regarding the coverage obtained in dusting peach trees by airplane. Colorimetric tests he found showed not only a higher percentage of coverage—nearly 100%—but a much higer percentage of coverage on the underneath sides of the leaves than was obtained by the use of large, power, dusters operated under the trees and discharging their dust directly against the underneath surfaces of the leaves.

Pecans have been dusted for pecan scab and case bearer; tomatoes for tomato worm, nail head, and leaf hopper, using calcium arsenate, copper lime dust and calcium cyanide which, incidentally, necessitates the pilot's flying with a gas mask. Cantaloupes have been dusted for the downy mildew, using sulphur; grape mildew control with sulphur dusting, and, in health work, the Anopheles malaria mosquito controlled by dusting the marshes and lakes with Paris Green. This was used at the rate of about a pound per acree and diluted with kalinite, or fuller's earth, as a filler. It was found that where as many as twenty-five particles of Paris Green were distributed to a square inch that a little over 90% of the Anopheles larvae were killed. In one experiment, where some three miles of lake and swamp were dusted with 300 lbs. of Paris Green, under the direction of Dr. W. V. King of Mound, Louisiana, ninety-seven per cent (97%) of the Anopheles larvae were killed within two hours, while the amount of Paris Green distributed was not in sufficient quantities to endanger persons or livestock in the vicinity, or sufficient to harm even the small minuows in the lake.

Sugar cane dusting for moth stalk borer was done in cooperation with the Louisiana State University, under Dr. W. E. Hinds, who is on the program and can give in full detail the results obtained in this control work. An interesting sidelight on the cane dusting in which sodium fluosilicate was used was brought to light while cleaning the grass and vegetation from one of the dusted fields a few days after the application was made. The workers found in this field some six or eight dead rats, while in no other plot or field was this the case. However, no other work has been done to check this observation.

Airplane dusting has also been conducted on the hemlock forests of the North for control of the hemlock span worm and on wheat fields for the control of rust.

In Utah experimental dusting for alfalfa weevil has proven successful. In the commercial operations only such dusting is done as has been found by Experiment Stations and the Government Laboratories to be entirely successful. However, cooperative work developing additional uses for the airplane in agricultural fields has been done in cooperation with Dr. Coad at Tallulah, La., Dr. King of Mounds, La., Dr. Snapp in Georgia, Dr. Hinds of Baton Rouge, Professor Kidder in Canete, Peru, and work has been outlined for the coming year with Dr. Thomas of the

Texas A. & M. Cooperative work has also been done in cooperation with Dr. A. W. Morrill of Los Angeles on tomatoes in Mexico.

There is a certain appeal to the average man in dusting by airplane. The work is spectacular, being classed among the most hazardous types of flying and, I might state at this point, that it makes particular demands both upon the pilot and the plane. While the pilot must be an expert pilot, expert flying is but an incident in the operation as he must be primarily a duster and all good pilots do not make good dusters. He must not only cover the ground at approximately 100 miles per hour, watching for obstacles, controlling his dust cloud and skimming the tops of the cotton, or other crop, by a very low margin, as you will see in the moving picture shortly, but he must watch his dust cloud, adjust his swaths according to the poundage he is applying and according to the wind velocity and the type of dust that he is using.

A successful dusting ship is a contradiction to what has been generally accepted in the flying qualities of an airplane. It must have a slow landing speed, in order to operate out of the pastures and fields as found on the average plantation, and at the same time it must be fast. It must be extremely maneuverable—at the same time it must carry a heavy load. It must be light, of course, yet rugged, and it is highly important that the split axle or tripod type of landing gear be used, as an axle between the wheel might easily prove disastrous in event of a forced landing in a standing crop. It should also be well powered, as an ample power reserve is particularly desirable when approaching trees 100 feet high at 100 miles per hour and the farmer expecting every plant in the field to be thoroughly covered. The hopper feed must be constructed so as to apply the dust in a ratio in proportion to the speed of the plane.

In our operations we have found two types of ship desirable; a smaller type capable of carrying from five to seven hundred pounds of dust per load for use in smaller fields where greater maneuverability is required, and a larger type, carrying fifteen hundred to eighteen hundred pounds, for use in large, open, sections such as are found in the southwestern states.

In the experimental dusting that has since been carried on in various countires most of the difficulties encountered and, in some cases, discouraging results have resulted largely due to the fact that these experiments have been conducted with ships not adapted for this type of work and with personnel inexperienced in this class of flying, and in the distribution of dusts. However, the work is gaining headway and new uses for the agricultural airplane are comming to light almost daily. I believe that the motion pictures following will give a much better idea of the operation and almost perfect dust cloud obtained by the airplane.

I see that the operator has the machine ready, so will continue by presenting the picture.

Report on

Sugar Cane Moth Borer Control through Utilization of Corn as a Trip Crop

By W. E. Hinds.

(The above paper is included in a detailed report by Dr. Hinds under the title "Sugar Cane Borer Control aided through Utilization of infested and Trap Corn" and published as Bulletin No. 198, Louisiana State Agricultural Experiment Station, Baton Rouge, La., April, 1927).

Parasites of the Moth Stalkborer

by *T. E. Holloway*

We already have in Louisiana the egg parasite, *Trichogramma Minutum* Riley. We realized that it would be very desirable to have a parasite of the larva, and so we introduced *Lixophaga diatraeae* Towns., which is now known as the Cuban thachinid.

This parasite was first noted by Dr. Geo. N. Wolcott, who is now in Haiti. In 1915 the Bureau of Entomology sent Mr. U. C. Loftin to Cuba, and he traveled over the island for about six months, visiting many centrals and collecting parasites and sending them to me at New Orleans. Many breeding methods were tried there but all failed and finally the parasites were liberated in the fields. One was recorded the same year, showing that the Cuban tachinid would attack the borer in Louisiana.

On account of lack of funds and for other reasons the work was discontinued, but in 1918 an enterprising Louisiana sugar planter, the late Mr. Clark D. Lebermuth, succeeded in raising a fund and I was sent to Cuba to collect the parasite. Over 600 were sent to Louisiana and some were placed in field cages while others were released in the fields. The cage results were disappointing and none were recorded in the fields from this yar's work.

In 1919 Mr. E. R. Barber collected parasites in Cuba and Mr. D. E. Haley and I released them on three widely separated Louisiana plantations. They were recovered the same year at all three places. The following year (1920) the sugar planters raised another fund and Mr. Barber and four student assistants were sent to Cuba, while Mr. Haley and I received the parasites in Louisiana. Over 6,000 parasites were sent and a high percentage reached Louisiana alive. They were released on about 40 plantations, all of those contributing to the fund. During subsequent years the parasite has been recorded on about 80% of these plantations.

However, only a trace of the parasite was found every year and this only during the grinding season. If one or two hundred stalks of cane are cut open and carefully examined on a plantation where the release was made, one puparium of the parasite or perhaps a dead borer which could have been killed by nothing but the parasite, is found.

There is thus a continual attack made on the borer, and it is my opinion that the planters have received full value for their money, but as for control of the borer this does not occur.

The reason is found in the cold winter and long dormant season in Louisiana. From about December 15 to about March 15, no cane is above ground and the borers do not appear in any numbers until much later. The parasite is living nicely in the fall but this unfavorable winter season comes and undoubtedly destroys a great percentage of the parasites.

By cooperation with Mr. Swezey and Mr. Muir of de Hawaiian Sugar Palnters Experiment Station we have also introduced *Ceromesia sphenopheri,* a parasite of the weevil borer. Neither the Hawaiian entomologists nor we ourselves expected it to attack our moth borer, and it did not.

We have also tried, through the efforts of Dr. L. O. Howard, Chief of the Bureau, a parasite of the European corn borer. This is *Habrobracou biericornis.* It was found to attack the borer readily when larvae were given to it, but it could not reach larvae in the stalks of sugar cane. About 4,000 individuals of this parasite were released at two places, and the species was never recovered.

There are two more parasites in Cuba which we want to introduce. These are *Bassus stigmaterus* and *Apanteles diatraeae*. By cooperation with the Cuba Sugar Club Experiment Station of the Tropical Plant Research Foundation we hope to bring these in this year.

Cuban Parasites of the Moth Stalkborer

H. K. Plank

As the opportunity presented itself, especially in the field examinations made in the study of borer injury and development, some very interesting data on the parasites of the borer have been secured.

The "Cuban fly", *Lixophaga (Euzenilliopsis) diatraeae* Townsend, a tachinid parasite of the larva, was encountered most frequently. In one locality in July, from 10% to 20% of the borers found in fifth ratoon cane, then about two months old, were parasitized by *Lixophage*. A month later this parasitism increased to about 38%, and to about 40% in September. In another locality in April, only 12½% of the borers found in first ratoon cane, then about 1½ months old, were parasitized by this fly and this parasitism never reached more than about 6% until November, when only about 8% of the borers were found parasitized. On January 15, however, when the cane was about ten months old, the total parasitism of the borer by this insect was about 15%.

The above figures were compiled from examinations in unburnt fields. During the past season some examinations have been made in burnt fields in an effort to secure some figures fhich would be indicative of the effect of burning on the abundance of *Lixophaga*. Accordingly, two adjacent fields of fifth ratoon cane were selected, one of which had been burnt over every year since the first. The cane in the two fields had been cut on February 20, 1926, and the trash in one of them was burnt about five days later.

An examination in the burnt field on April 25, when the cane was about two months old, revealed no parasites; the next examination on June 10 showed 6.2% of the borers parasitized by *Lixophaga;* and on January 13, 1927, when the cane was about eleven months old, the parasitism by this fly was 13.7%.

In the adjacent unburnt field the April 25 examination showed that 4.7% of the borers found were parasitized by *Lixophaga;* on June 9, the parasitism was 15.3%; and on January 13, 21.8%.

In this connection it should be noted that a status examination, made on January 13, showed in the burnt field 14.7 infested stalks per cepa, 93.6% of all the stalks infested, and 24.42% of all the joints; while in the unburnt adjacent field these figures were 8, 91.4% and 18.37% respectively.

Bassus stigmaterus Cresson, an ichneumonid parasite of the larva, was next in importance among the parasites found. It comprised from 2/3 to all the parasites encountered in the examinations of first ratoon cane in one location from May, when the cane was about two months old, until November. During this time, however, the greatest parasitism of the borer by this species was only about 7%. One larva was found parasitized by this insect in the January examinations. It is interesting to note that no *Bassus* parasites were taken in fifth ratoon cane.

A species of *Microgaster,* a braconid parasite of the larva, was found quite generally distributed regardless of the age of the fields. It appeared in greatest abundance about late September and early October, when it comprised about half

of the parasites found then and parasitized about one-fourth of the borer larvae in some places.

What is believed to be *Sarcophaga sternodontis* Townsend, a sarcophagid fly parasite of the borer pupa, has been reared from a few pupae taken during the months of April and October. It does not appear to be very abundant in the region under observation.

In a number of instances borer larvae and pupae have been found killed by what is thought to be the fungus parasite *Cordyceps barberi* Giard. This fungus was found mostly during May and June, but is comparatively rare.

The parasitism of the borer by all these parasites collectively varies greatly throughout the season and apparently according to the age of the field and of the cane. For example, in several fields of first ratoon cane in April, about one month after the previous crop was cut, the total parasitism of the borer was found to be 12.5%; this fell to 5.3% in May; rose to 10% in June, and to 16.6% in July; in November it dropped to 11%, but rose to 19.2% in January.

In some fields of fifth ratoon cane in late July, two months after the previous crop was cut, the maximum parasitism of the borer was found to be as high as 20% in one field with the average of four fields being 16.7%; about two weeks later it went to 38.9% in one field with 22.6% the average of four fields; in late August, it varied from nothing to 38%, the average being 24%; about a month later it was found varying in four fields from nothing to as high as 53.8%, the average being 16.6%; while one field on October 23 went as high as 57.1%. In December, when the cane was about seven months old, the average parasitism of the borer had dropped to about 22%.

It is rather difficult to say what effect applications of arsenate of calcium and of sodium and calcium fluosilicate dusts might have on the parasites of the borer. In the dusting work it was generally noted, however, that Lixophaga was more abundant in the cane dusted with arsenate of calcium than where the above fluosilicates were applied. This may have been partially due to the fact that these fluosilicates reduced the borer population to a considerably greater extent than did the arsenate of calcium treatments.

The Losses from the Sugar Cane Moth Borer in Cuba.

By *J. T. Crawley.*

I will give the mill loss of one plantation during three months of the past grinding season, and estimate the loss of the mill during the period. The method consisted in taking 50 or 100 stalks of cane at random from a car of cane or from the cane carrier and dividing the same into sound canes and canes showing borer holes, which is the usual method of estimating the per cent of borer infestation The two lots of stalks, or parts of them, were then passed separately through a hand mill and the juices analysed. From the data collected, and knowing the factors of efficiency of the mills, the estimated yield was calculated.

In all 291 cars of cane and covering a period of about three months were sampled, and while individual small samples passed through a hand mill may not give reliable data, yet I thing that you will agree with me that the averages taken from such a mass of data will give a pretty good idea of the loss that is being sustained by the mill in question and for the period covered by the data.

Without going into detail, the data showed that 17% of all the cane examined had been attacked by the borer and that the loss was roughly 2% of the yield. In other words, a factory with a crop of 500,000 bags and having cane similarly injured by borer would sustain a loss, say, of 10,000 bags of sugar from this cause alone during the season. Now there is nothing startling about these figures, yet it must be remembered that it is a loss being sustained year after year without its becoming very apparent to the mill owner, and during a long series of years it would result in figures of a startling nature.

I have presented these figures simply to show one method that one mill has employed in estimating its loss and not at all to show the total damage caused to the industry by the borer. We find that if we can show an owner where he is sustaining a loss of 2% in the factory we can interest him, and very often to the point of taking vigorous action to overcome it, whereas a 25% loss in the field might not interest him very much.

It has been stated before this Congress that the borer is of little economic importance to Cuba and I wish to state as trongly and as forcefully as I can that this statement is not borne out by the facts. During the past two years, that is, during the grinding seasons of 1925 and of 1926, I have had occasion to investigate this subject rather thoroughly on eight Cuban plantations. On two of these the infestation was under 15%, and on the others it was over 15% and ran up as high as above 30%. Even with a loss of 2% in the factory, which is much less than is sustained by several of them, the figures are quite impressive, but there is a far greater loss in the field. I know of one colonia of a thousand acres of cane where the loss was at least 16,000 tons of cane in one year. My opinion is based on the fertility of the soil, the rainfall, the condition of the cane, and comparing the actual yield of the fields with other near-by fields which were not so badly attacked by borers, and by cane in the same colonia itself which was allowed to reach maturity without having been greatly injured. There are fields, and of large axtent, where the cane has been so badly injured that it was not worth harvesting. I know of one factory where the yield became so low toward the end of the grinding season that it almost caused the closing of the mill before the crop was finished. The manager of the plantation estimated that the cane being ground at the time had a borer infestation of over 40%, and he reported that the sugar in the cane that was sound was 15%, while that in the borer cane was but one-half of that figure, and my own calculation showed that the average sucrose obtained by combining the two lots of cane was in fact almost exactly what the laboratory reported for the total cane ground on that date.

The eight plantations covered by this investigation are situated in the Provinces of Santa Clara and Camaguey and at the same time I have had opportunity to see several plantations in the Province of Havana. In one particular case the field superintendent showed me a field of ratoons which he said that he had fertilized and carefully cultivated the previous year because they were in bad condition and about to fail. His work was a failure and the cane was dying, and and investigation showed that it was being killed by the borer, and I am inclined to think that other cases of ratoon failure have been brought about in the same way.

I know that it has been generally believed that the borer is of no economic importance in Cuba and you often see such statements in the sugar journals, but the facts do not bear this out, and its constant reiteration does not make it true. It is very advisable that the public and private institutions represented at this Congress

should adopt measures that would foster cooperation of some kind in the prosecution of work in which all or a considerable number are interested, and it has occurred to me that the study of the cane borer and the introduction and propagation of parasites of the same might be carried on cooperatively. This is a large question; the hunting for parasites and their propagation is a difficult and expensive matter, too large to be handled successfully by private enterprise or by single institutions. But if we could in some way bring those private and public enterprises together cooperatively we might look for important results.

Some Grasses that Harbor the Sugar Cane Moth Stalkborer in Cuba.

By *H. K. Plank.*

During the past summer, what is thought to be the larvae of the sugar cane moth stalkborer were found in corn and six grasses which commonly grow in or near Cuban cane fields. The larvae in the grasses were of course rather small in comparison with those ordinarily found in cane and it was not always possible to keep them alive in the laboratory until the moth could emerge; but while a positive determination by specialists of the speciments secured is lacking, it might be said here that from their appearance and the character of their work they seem to be the same moth borer which infests sugar cane. Five of the grasses were identified by Dr. M. N. Walker, formerly pathologist of the Cuba Sugar Club Experiment Station, and the "caña santa" was identified by Mr. C. F. Stahl of the same station.

As might be expected, corn was found very heavily infested, as many as ten borers being found in a single stalk.

"Sour-grass", or "rabo de zorra", (*Valota insularis* (L.) Chase) was found more heavily infested than any of the other grasses, up to about 77% of the stalks in a number of stools in one location being bent over or showing other evidence of borer attack, and many of them containing larvae and pupae of various ages. This grass grows abundantly and is generally distrbuted in many cane fields, along the guarda-rrayas, and along the railroad banks.

Three other grasses were found fairly heavily infested, although not nearly so much so as "rabo de zorra". These were "pata de gallina" (Leptochloa virgata (L.) Beauv.), "grama pintada" (*Echinocloa colonum* (L.) Link), and "grama de caballo" or "pata de gallina" (*Eleusine indica* (L.) Gaertn.). The last two of these were found infested only at the mill, where, possibly for the lack of more suitable hosts, the moths emerging from infested canes dropped from the cars were forced to deposit their eggs on these grasses. However, all are more or less widely distributed and very abundant in some cane fields, where they may act as harboring places for the borer.

"Natal grass" or "yerba natal" (*Tricholaena rosea* (Li) Nees) is another grass in which borer was found. This grass is very common along railroads and guarda-rrayas in many Cuban cane growing regions, and it is, therefore, fortunate that only a very few stalks have thus far been found infested.

One of the ornamental grasses, known locally as "caña santa, yerba de limon or yerba santa" (very probably *Andropogon schaenanthus* Lin.) and commonly grown i nthe bateys for ornamental and medicinal purposes, has been found to harbor the borer to a considerable extent. In several places many of the stalks of this grass were found bearing much evidence of borer injury and containing numerous living borers.

While the exact extent to which these grasses might act as sources of borer infestation for Cuban cane fields is not definitely known, it is certain that, as previously referred to, the borer infestation in a cane field usually is greatest near grassy guardarrayas or old pastures which contain particularly "rabo de zorra". Good plantation management would, therefore, suggest the elimination of these grasses so far as possible from both the cane fields themselves and the surrounding guardarrayas.

Work with Parasites of Sugar Cane Insects in Hawaii.

By *H. P. Agee*

LEAFHOPPERS

During the early work of the Experiment Station, H. S. P. A. begun in 1895, there were no entomological or pathological departments.

When the outbreak of leafhoppers occured in 1903, or shortly prior thereto, by fortunate circustance Dr. R. C. L. Perkins was in Hawaii doing work on the Hawaiian insect fauna for a British Society, and Prof. A. Koebele was in California. The latter's work in controlling the cottony-cushion scale through introduced natural enemies suggested the possibility of biological control of the heafhopper in Hawaii. The services of both Prof. Koebele and Dr. Perkins were engaged. The early work was under the auspicess of the Territorial Government, financed by the sugar planters. Later the work became a part of the Experiment Station activities.

The extent of the leafhopper damage was so severe that by 1905 one plantation had closed down and others were in great distress, in fact, the life of the industry seemed doomed.

After explorations in Australia several species of egg-parasites of the leaf-hopper were found and successfully introduced. These were *Paranagrus optibiles, Ootatrastechus beatus,* and *Anagrus* sp. These attack their host by depositing their eggs within the egg of the leaf-hopper. The parasite develops by feeding upon the leaf-hopper eggs.

So great was the relief afforded by these parasites that within two years or thereabouts the leaf-hopper scourge had been reduced to a point that enabled the industry to take on new life. The leaf-hoppers continued in evidence, however, but their damage had been reduced by perhaps 90% or more. Each spring on some plantations a definite increase in their numbers could be observed, to be followed, toward early summer, by an increase in the parasites and a suppression of the hoppers. Occasionally obstinate outbreaks occurred and continued for several months, doing definite damage to small areas. In 1916 another egg parasite, *Oootatrastichus formosaun,* was introduced from Formosa by Mr. F. Muir. This was an aid, but persistent outbreaks became particularly troublesome between 1915 to 1920 and caused heavy losses on a few plantations. The final and completely satisfactory control of the leaf-hopper did not occur until after the introduction from Australia by Mr. F. Muir, of the egg-eating bug, *Cyrtorhunius mundulus,* in 1920. After almost a year of discouraging work in Australia this valuable insect was discovered and a small colony was brought to Honolulu. It is of interest to note that specimens of *Cyrtorhunius mundulus,* taken in Fiji years earlier, were in the Honolulu collections, its habits of feeding on hopper eggs being unknown. On this evidence Mr. Pemberton left for Fiji shortly after Mr. Muir's return to get additional colonies to strengthen the colony brought by Mr. Muir.

Cyrtophunius did not become strongly established for some time, but after about two years it appeared in numbers in both the wet and dry districts. The troublesome outbreaks disappeared. The seasonal increases were no longer noted in appreciable degree, and the battle against the leaf-hopper begun nearly twenty years previously was won.

CANE BORER (RHABDOCNEMIS OBSCURUS)

The initial control of the leaf-hopper was so satisfactory compared with the early days of disaster that the planters agreed to the proposal of Mr. F. Muir to undertake explorations toward a biological control of the cane borer. This pest had taken its toll of the sugar crops since the beginning of the industry, it evidently having found its way to the Islands in cane brought by the natives prior to the discovery of Hawaii by Europeans.

After three or four years in the Islands of the South Sea, with extreme difficulties of travel and living conditions and despite illness contracted in the work, a Tachinid fly, parasitic upon the borer, found in Amboina, was finally introduced and established in Hawaii by Mr. Muir. Repeated efforts to bring the parasite direct to Honolulu by way of the Orient failed. Success resulted at last by establishing relay breeding stations and propagating new generations of the fly for each stage of the journey which took the following couse: Amboina to Australia, thence to Fiji, thence to Honolulu. The cooperation of the government authorities and the officials of the Colonial Sugar Co. of Australia and Fiji contributed to the success of the enterprise.

New colonies were bred in Honolulu and within a comparatively short time the Tachinid fly was established on most plantations. The Kau district proved an exception and it was not until several years of repeated trials that the fly was established there.

The control of the borer as against its original damage might be estimated roughly as between 80 and 95 per cent. In the Hamakua district where the D 1135 cane lodges badly the damage is still considerable. The entomologists are working toward a more complete control of the borer. Mr. C. E. Pemberton has been in the Philippines and Dutch East Indies for two years exploring for other natural enemies. He has found a fungus which is parasitic upon the borers, and attempts to establish it in Hawaii are being made.

ANOMALA BEETLE

Anomala orientalis, was first recognized as a cane pest in 1912 or 1913 when it had begun to do severe damage to certain fields of the Honolulu Plantation Co. Having found it to be a Japanese insect, through the British Museum, Mr. Muir in March 1913 undertook to find natural enemies. I heard much doubt expressed as to the ability of the Hawaiian entomologists to control a white grub through parasites. Much work had been done elsewhere on white grubs without success and the difficulties appeared enormous. Several parasites on Anomala were found in Japan. Repeated efforts to establish them in Hawaii failed. Mr. Muir then worked further south, first in Formosa, then the Philippines. There a successful parasite was located. It is a remarkable example of biologic control, for the pest itself, *Anomala orientalis,* does not occur in the Philippines. The small black wasp, *Scolia manilae,* preys upon other related species and upon introduction to Hawaii proved most effective on *Anomala orientalis,* so much so that the pest has never spread beyond the

second plantation. However, since the Scolia wasp also preys upon the Chinese Rose Beetle, the entomologists now have the satisfaction of seeing this parasite established on the four islands of the group, while *Anomala* is yet confined to a part of the Island of Oahn. This project consumed about 3½ years of foreign work.

GENERAL

This brief statement of the control of three major cane pest in Hawaii omits many important details which can best be supplied by the entomologists who have participated in the work.

Mr. O. H. Swezey has been connected with all the projects mentioned, in receiving and caring for material sent to Honolulu. Both Mr. Muir and Mr. Swezey have been with this work over twenty years, they having joined the staff of entomologists during the early campaign against leafhoppers, headed by Prof. Koebele and Dr. Perkins. Others who have participated in the Hawaiian entomologists work are: Mr. Kershaw; Mr. Osborn, with us at this meeting; Mr. Timberlake and Doctor Williams. Dr. Henderson and Mr. Hadden have recently joined the staff.

Many instances of successful introductions of beneficial insects on minor pests are of record as well as many on the pests of plants other than sugar cane. A list of these was prepared by Mr. Swezey at which time he brought attention to the fact that success follows repeated efforts and that the number of species of parasites that have been imported into Hawaii without being successfully established exceeds the number that has become established.

The parasitic control of insect pests in Hawaii has been due in great degree to the fact that our entomoligsts have an abiding faith in this method of attack. They are backed by business men who have firm faith in the entomologists and make no question as to the time and funds spent in foreign explorations.

A memorandum, prepared by Mr. Swezey is attached, giving an outline of the foreign work that has been done.

Mr. Fullaway and Mr. Ehrhorn of the Territorial Board of Agriculture and Forestry have given ready cooperation to the entomologists of the H. S. P. A. Mr. Fullaway has done important foreign work for that Board.

MEMORANDUM ON EXPLORATION TRIPS BY ENTOMOLOGISTS OF THE HAWAIIAN SUGAR PLANTERS' EXPERIMENT STATION FOR THE PURPOSE OF DISCOVERING AND INTRODUCING BENEFICIAL INSECTS.

Compiled by Otto H. Swezey.

Trips by Albert Koebele.

Before the Department of Entomology was organized at the Experiment Station in 1904, Mr. Albert Koebele, as Government Entomologist since 1893, had been traveling to various regions about the Pacific in search of beneficial insects for introduction to Hawaii. No detailed records are available of the definite dates of these earlier trips, nor of the length of each. In 1894-5 he traveled in Australia, Ceylon, Hongkong, China and Japan. In 1896-7 about half the period was spent in California, Arizona and Mexico. In 1899, was another trip to Fiji, Australia and Hong-

kong. May-December, 1902, was spent in Mexico, studying and introducing insects to check lantana. August-October, 1903, Ohio, working with leaf-hopper parasites.

After the Department of Entomology was organized at the Experiment Station, H. S. P. A., in 1904, Mr. Koebele's trips were as follows:

1904, May 11 to December. Australia with Dr. R. C. L. Perkins, working with sugar cane leaf-hopper parasites.

1905, January to April. Australia and Fiji. Leaf hopper parasites.

1906, April to December. California and Arizona. Horn fly enemies, Mealy bug enemies, and Miscellaneous.

1907, October to December. Mexico. Cane insects and parasites.

1908-1912. Germany. Summer time work on horn fly enemies.

Trips by F. Muir.

December 1905 to June 1906. Fiji. Leaf hopper parasites.

July 1906 to January 1907. China. Leaf hoper parasites.

1907. (Malay States, Java, Borneo, Amboina, Larat) Sugar cane beetle borer parasites.

1908. Amboina, Hongkong, Ceram. Sugar cane beetle borer parasites.

1909. Ceram, Macassar, New Guinea. Sugar cane beetle borer parasites.

January 8 to August 16, 1910. New Guinea, Queensland, Fiji, (with Kershaw). Sugar cane beetle borer parasites.

March 28, 1913 to November 17, 1914. Japan, Java (Anomala grub parasite).

May 28, 1915 to March 2, 1916. (Japan, Formosa, Philippines). Anomala grub parasite.

April 28 to November 6, 1916. Philippines.

May 18, 1919 to June 21, 1920. Australia. Leaf hopper enemies.

Trip by H. T. Osborn.

October 16, 1915 to July 31, 1916. Philippines. (Anomala grub parasites).

September to October 18, 1916. Japan. Anomala grub parasites.

August 24, 1921 to October 31, 1922. (California, Mexico). Horn fly enemies Mealy bug enemies.

(For Board of Agriculture)

November 1, 1922 to November 4, 1924. Mexico. Army worm parasites Pamakani insects.

Trip by F. X. Williams.

May 1916 to October 12, 1917. Philippines. Anomala grub parasites.

February 10 to August 19, 1919. Australia. Leaf hopper enemies.

September 25, 1920 to April 28, 1922. Philippines. Wireworm enemies. Fig insects.

August 1, 1922 to July 28, 1924. (Panama, Ecuador, British Guiana, Brazil.) Wireworm parasites and Miscellaneous.

Trips by C. E. Pemberton.

July 28 to December 9, 1920. Fiji. *Cyrtorhinus mundulus.*

December 9, 1920 to March 5, 1922. (Australia). Wireworn parasites Fern weevil parasite. Fig insects.

February 13, 1925 to February 1927. (Philippines, Java, Borneo, Celebes.) Sugar cane beetle borer enemies. Nut grass insects, Mole chicket parasite.

PLAN FOR A COOPERATIVE INTERNATIONAL ORGANIZATION FOR PARASITE INTRODUCTIONS

By Harold E. Box of Porto Rico.

(Presented by Mr. A. H. Rosenfeld of Louisiana)

While I fully recognize that artificial methods of control against sugar-cane moth borers of the genus *Diatraea* may prove effective in realing with local outbreaks of this pest, I feel convinced that in order to make any *general* reduction in the enormous annual losses due to this insect in the various countries in which it exists, the employment of the so-called "biological" method is more likely to prove successful. There are, I know several entomologists who doubt this statement, but nevertheless it must not be forgotten that it receives the approbation of many entomologists of distinction, in whose footsteps I claim to be a humble follower.

The value of the natural enemies of *Diatraea* in contributing to the sugar production of countries in the New World has long been recognized, and it would be no exaggeration to state that without them the production of cane sugar would not be profitably undertaken in many of these countries, owing to the type of damage that *Diatraea* inflicts upon the plant at all stages of its growth and the enormous potential breeding capacity of this pest. But it so happens that *in spite* of the existence of various parasites upon borers the latter are still able to levy a heavy tax upon sugar production, amounting to a sum of which the most conservative estimate is not less than ten million dollars annually for North, Central and South America and the West Indies.

Frequently by a study of local conditions the indigenous parasites of a country can be increased (with a corresponding decrease in *Diatraea*) by altering some local custom which prevents the parasites from giving their maximum benefits, but on the other hand it must be remembered that there is always a limit to the effectiveness of a native parasite, beyond which (except for some very exceptional occurrence) it cannot pass. This same parasite, transported elsewhere where it finds an abundance of borers but none of the factors (I am speaking entirely theoretically) which limit its increase, may go right ahead an cause heavy mortality among its hosts before stopped by natural conditions. It is by taking advantage of this circumstance that success has so often followed the introduction of foreign parasites as means for combatting insect pests, though at the same time it must be remembered that the system is entirely speculative, and definite results can seldom, if ever, be correctly anticipated.

Already some very notable attempts have been made by enterprising organizations in several countries towards introducing parasites of the major enemy of the sugar-cane industry, and recently (July, 1926) I have published some account of these experiments, together with a list of the parasites of *Diatraea* known to me at that time. This article appeared in the "Reference Book of the Sugar industry of the World" and may perhaps have come to the notice of some of the gentlemen here present. My present object is to lay before this assembly for discussion an idea which I propounded in the article just referred to, namely, that there be organized a body of entomologists to study the borer question wherever it is of importance, with the view of effecting, if possible, the universal control of this pest by means of its natural enemies.

It is with the greatest regret that I am not able to be present at this meeting to hear the views of men far more experienced than myself, and whose opinions I

would most gratefully appreciate, but I feel that in my good friend Mr. Rosenfeld I have a valuable, experienced, and capable protagonist, who will act on my behalf.

Many of the entomologists present will surely recollect that during the last year I have been soliciting from them their opinions upon this subject, and I desire to take this opportunity of thanking them for their most interesting and encouraging answers to my letters. I particularly want to thank Dr. H. P. Agee for giving consideration to my suggestion that time be set aside during this Convention for a discussion of the Cane Borer Question, and also Dr. W. A. Orton for the kindly interest he has several times demonstrated towards this matter. Dr. L. O. Howard, the Chief of the U. S. Federal Bureau of Entomology is also greatly interested in dveloping this scheme, and promises his most valuable support in any project that may result from the discussion which I hope will follow the reading of this paper. Dr. G. A. K. Marshall, Director of the Imperial Bureau of Entomology, London, England, is also interested in aiding this project in any way that he can.

It is quite beyond my power to offer any practical suggestion as to how to properly organize such a co-operative scheme as I have in mind: I am interested in the matter from the entomological point of view, but I feel sure that there are present many who are capable and willing to offer their ideas on this as well as the most important question of all, namely, the obtaining and subsequent handling of the necessary finances. I do not think I am committing a breach of confidence if I mention that Dr. Agee thinks that the Tropical Plant Research Foundation could admirably handle the matter, a suggestion which I feel sure will meet with the approval of all.

Provided that it is acknowledged that a campaign of parasite—introduction is going to prove advantageous, it surely does seem reasonable to suppose that better results are likely to be obtained if the entomologists engaged in such work are stationed more or less permanently in one place than if the work is carried out by men traveling and able only to get a rough idea of local conditions (and far from the average ones) in the countries visited. My main idea is to do away with the traveling entomologist entirely, and allow the work to be done in the way of continuous "exchanges", using central headquarters for shipping parasites where steamer services are lacking. The several other important advantages of a cooperative system will surely be obvious, and need no mention in this paper, which is intended to be brief.

Considering the enormous importance of *Diatraea* as a pest of valuable food crop, it is really astonishing how little is really known about its parasites. The life histories of all but a few are entirely unknown, and where known are published in obscure journals not always available to the average worker with limited library facilities. Even the nomenclature is in a state of disorder and from my own experience I can state that about a dozen of the hymonopterous parasites known to attack *Diatraea* in South American countries are unamed. And regarding the dipterous parasites, I believe I am right in stating that except for what has been written by Dr. Townsend upon *Paratheresis signifera* in Peru and by Mr. Rosenfeld upon what is probably the same fly in Tucuman (Argentina), no life history studies at all have been published. I have during my two years at Central Aguirre accumulated some data upon our local fly parasite of *Diatraea saccharalis,* which will shortly be printed, and this will form what I think is the first record of its kind upon the famous Cuban fly — *Euzenilliopsis* (or as it is now called — *Lixophaga diatraeae*). Yet this insect has already been exported to three countries outside the

Greater Antilles; Louisiana, Mexico, and British Guiana. How much more promising would have been the results of these importations had the entomologists been preinformed as to the habits, biology, etc. of the parasite in question.

The Cuban Braconid, sometimes referred to as an Ichneumonid, goes under several pseudonyms, and the man who comes to this Island in search of *Microdus* may later read of the such-and-such parasitism of *Diatraea* by *Bassus,* and come in search of the *Bassus,* to find that *Bassus* is *Microdus!*

For several years now I have been greatly interested in a Braconid which hides under the name of *Iphiaulax medianus.* Cameron in British Guiana, and about which much is written in that country. In Venezuela a Braconid identified for me as *Ipobracon grenadensis.* Ashmead, is the most valuable enemy of *Diatraea,* and I have been importing this useful wasp to Aguirre. I was fortunate in already knowing that the *Ipobracon grenadensis* is the same as Cameron's *Iphiaulax medianus;* otherwise I might have gone on to Demerara. Through knowing of the absolute identity of these apparently two different parasites, for which knowledge I am indebted to the specialists of the British Museum, not only has a long and probably expensive journey been obviated, but also the information gives a valuable clue as to the possibilities of this wasp in Porto Rico, and also elsewhere in this part of the world. A wasp with such a wide distribution and which is adaptable climatologically to both the hot humid coastlands of British Guiana and the cool heights of the Caracas district is surely promising for the Greater Antilles, where meteorological conditions approach the mean of these two extremes. This parasite I think would be well worth trying out in Cuba.

Sufficient has been said to show how much we need a central clearing house for information which can be circulated to workers otherwise isolated, and also prove a medium for the rapid exchange of results and ideas between the different workers on the *one same problem,* that I think I may close this paper, leaving it to others more competent than myself to deal with the various aspects of the matter that have not occurred to me.

I venture to move a vote, gentlemen, that a committee be formed for the purpose of discussing the question of the most effective means of combating our arch enemies—*Diatraea saccharalis* and its relatives.

Parasites Introduced into Formosa for Insect Pests of Sugar Cane.

Reported by *Dr. Migaku Ishida.*

During the year 1915 egg parasites of the moth borers, *Diatraea striatalis, Chilo infuscatellus* and *Sciropophaga auriflua,* were introduced into Formosa from Java. A total of 436 speciments were brought in, and those attacking *Sciropophaga auriflua* were recognized as a new variety, *Phanurus beneficiens* var. *elongatus* Ishida. *Phanurus beneficiens* Zehnt., the parasite of *Diatrea striatalis* and *Chilo infuscatellus* was artificially propagated, 421, 362 individuals having been reared during the period 1915 to 1926.

Forty specimens of *Diatraeophaga striatalis* Towns, a fly parasite of *Diatraea striatalis,* were also introduced from Java during the year 1915, but they were not artificially propagated.

Encarsia flavo-scutellum Zehnt, a parasite of the sugar cane aphid, *(Oregma lanigera* Zehnt.), was introduced from Java in 1926. 62,300 individuals were imported and more than 5000 were subsequently artificially propagated.

Another parasite, *Coelophora bipragiata?*, of the same aphid was introduced from French Indo-China in 1925. Five hundred individuals were brought in and later 8000 were reared.

Fifty specimens of a ladybird beetle *(Scymnus* sp) were also introduced from French Indo-China in 1925. This species was not propagated artificially.

PROCEEDINGS OF HAVANA CONFERENCE

SECTION III

SUGAR CANE DISEASES

J. R. Johnston, *Chairman.* E. W. Brandes, *Secretary.*

Sugar Cane Root Diseases, a Discussion.
Louisiana, C. W. *Edgerton* and *R. D. Rands.*
Cuba, *J. A. Faris.*
Hawaii, *H. P. Agee.*
Florida, *B. A. Bourne.*
Porto Rico, *J. Matz.*
Sugar Cane Mosaic. *By E. W. Brandes.*
Corn Mosaic. *By C. F. Stahl.*
Strains of Viruses Affecting the Gramineae. *By H. H. Storey.*
The Control of Sugar Cane Mosaic. *By J. T. Crawley.*
Frio Planting for Mosaic. *By J. Alfaro.*
Seed Selection and Roguing for Mosaic Control. *By R. Menendez Ramos.*
Statement on Mosaic Control. *By J. Alfaro.*
The Control of Sugar Cane Mosaic in the West Indies. *By R. Menendez Ramos.*
Spread of Mosaic. A Discussion.
Etiology of Mosaic. A Discussion.
Some Sugar Cane Leaf Spots in Cuba. *By J. A. Faris.*
Discussion of Leaf Spots.
Gumming Disease. A Discussion.
Cane Stem Galls. A Discussion.
Root Galls. *By J. A. Faris.*
Dry Top Rot. *By J. Matz.*
Downy Mildew in Formosa. *By T. Miyake.*

SECTION III

SUGAR CANE DISEASES

General Session, Afternoon of March 15th.

Remarks of Dr. C. W. Edgerton of Lousiana:

I hardly think it worth while this morning to go into the history of root rot as I think most of us have some idea or the various epidemics which have occurred in the various sugar countries in the past. Now, as we are to consider the subject this morning, I think it advisable to include all those things which are commonly

considered in the root rot complex. With our present knowledge of the root disease problem, it is better to consider all of these various topics. Now in the root rot complex as it is generally considered, we mean the failure of the plant to grow on account of the inability of the root system to furnish sufficient mineral salts and water to the plants. That is really what we mean by the root disease at the present time. In this there are a great many different factors. Among these things we would include the following: The presence of toxic substances, for instance, in the soil. This is probably an important phase of the work in Lousiana on account of our heavy rainfall, or rather poor drainage and the water from the river, especially in certain years. Right now the water from the river is seeping through the levees so that the water is running strongly in every drain ditch. Another thing that comes in is ratio of mineral salts in the soil, the improper ratio of magnesium, lime, manganese, etc. The other phases of the work are more or less of a parasitic nature. We have first the nematodes. We are working on these at the present time and find them very common in practically all soils of the sugar belt. The attack of soil animals, including everything, such as snails, worms, centipedes and things of that type, is important. In certain regions the cane becomes badly pitted by the attack of certain soil animals. This work was taken up by Dr. Rands in 1924, and you have probably seen his bulletins upon this subject. The last phase of root rot is the attack of fungus parasites. A great many of these have been described at one time or another as parasitic upon cane roots. We have a number of these in Louisiana which attack the roots, depending upon weather conditions and also upon soil conditions. Then the whole problem is mixed up with cultivation, drainage and weather conditions. It is the general opinion, which is probably true, that anything which retards the growth of cane is dangerous and bad for the cane plant, making the plant more subject to infection, that is, heavy rains in the winter season or a drought condition in the summer make root rot more severe. Now, until we can show the slides, I think sufficient has been said on the root problem.

Dr. R. D. Rands: What I have to say has already been reported in a preliminary article published in 1924, in which one or two of the factors in the complicated root disease problem in Louisiana were defined. In that circular attention was called especially to the damage from root gnawing animals, followed by root rot. The root pitting is due mainly to a small species of snail (Zonitoides arboreus), and a symphilid, or small white centipede (Hanseniella unguicalata). They attack the first roots that come out. Especially in Louisiana, retardation of the crop in starting off is serious because of the short growing season and consequent lower sucrose and purity of juice than would otherwise be obtained. The most important thing about this animal damage is the preventing of elongation of the roots, the tips of which are usually killed, or subsequently (and sometimes independently) rotted off. This attack on the soft white growing points prevents the expansion of the root system. In the dry season of 1924, I did not find very much rotting of the roots. The success of the plant in getting established in spite of such root mortality is complicated by the extent and time of seed decay. In Louisiana we have the seed decay problem, which is a very serious one, combined with this early root damage and in case of the old varieties necessitating the planting of 3-4 tons of seed per acre to be sure of obtaining a stand. The remaining plants die, in the months of April and May, even though rains are frequent. Later in the year, though we find much pitting of the roots, the damage is not so severe, but its earlier effect remains. Now from the beginning the difference in tolerance of the dif-

ferent varieties to this root disease complex was very evident, so accordingly with limited funds for the last two years we have been trying to determine which are best adapted to local conditions, because it is evident that if these varieties are suitable in other respcets the root-rot complex for the time being is solved. I hope, however, to continue my experimental studies. This last month I have extensive isolations and obtained a high percentage of one or more species of Pythium from pitted and rotted root tips. Such were also obtained during the cool spring months of 1925, but later during the hot months blackish lesions were common and usually I got Rhizoctonia.

Dr. James A. Faris: The study of the root disease problem in Cuba as begun by us about two years ago was based upon a general survey of the Island cane fields in which we attenpted to differentiate various cases of cane failure. It is clear from the publications of previous investigations in Cuba, as well as of those in other countries, that the root disease problems are very largely tied up with soil conditions.

In order to get this straightened out in our minds and to determine whether we have any particular case of root trouble associated with particular soil types, we brought Mr. H. H. Bennett, from the United States Bureau of Soils to make a general survey, particularly emphasizing the point of the dying out of cane. In the first place, we have here an Island 800 miles long, having some areas and soils that are not adapted to cane growing, but it is a hard proposition under the present conditions, at least, to convince some of the growers to leave such areas out of sugar cane. The survey resulted in the determination of almost 100 soil types, and it was found that the root disease in Cuba is greatly complicated by very great differences in soils from one area to another. We are dealing with a group of soils that are, in general, extremely heavy and of high clay content, soils which are very difficult to handle at certain seasons of the year. For that reason we have a great many cultivation problem entering in the root disease situation. I make reference to two articles in "Phytopathology" of February, 1927, in one of which Dr. Allison and I have discussed the general root failure problem in Cuba, and the other upon a zonate foot rot of cane.

(Lantern slides shown by Dr. Faris)

(Lantern slides showing pitting of roots and effect of Pythium, shown by Dr. Edgerton).

Mr. H. P. Agee: We have in Honolulu a situation which formerly went under the name of Lahaina disease and which came to be known as the root disease complex of sugar cane. Without going into much detail I may say that we have organized the work so that we have chemists working on it, as well as entomologists, pathologists, and agriculturists. We recognize Pythium and nematodes, both gall-forming and others. Also the roots can be injured or their growth clecked by toxic accumulations. We also recognize that cane roots are attacked by various soil animals other than nematodes, among which are centipedes, snails, and other minute soil animals. A study has been made of the soil animals other than the nematodes. We have reached the conclusion that while they are important, their importance is minor. We find very few of these minute snails, except occasionally on low lying fields. Honolulu findings may have no bearing on the Louisiana situation.

We have recently read with much interest a letter that Mr. F. S. Earle wrote "Facts About Sugar" regarding the work we are doing. He wondered why we had lost sight of the principal factor, the need of good dirt farming, in which he considered Hawaii rather lax. As a matter of fact, the fields where Lahaina failed gave excellent yields when planted to H 109 and this indicates that there was nothing wrong with their physical condition. Yet after several crops of H 109, Lahaina again failed when planted experimentally. The situation today is that we do not suffer any great injury from root rot. The Lahaina trouble has been largely eliminated by substitution of H 109 and other resistant varieties for the Lahaina. Mr. Moir is familiar with this trouble from the plantation standpoint.

B. A. Bourne: In any pathological problem, it is necessary of course to isolate all the factors, specially in a problem like this in which so many factors are taking part, both chemical and physical. Recently I attempted to determine exactly which organisms can enter the root of cane without the aid of any mechanical injury. I think that is a very important and primary consideration that should be worked out. It has a number of problems connected with it and the first problem that should be solved is, of course, to obtain pure cultures of the cane plant. I have been very fortunate to be able to do this by means of seed sterilization, using the sexual seed. Having produced pure cultures of sugar cane in culture tubes under aseptic conditions I have attemped to inoculate these with single spore strains of the pathogenes. As the work has developed I have discovered so far that two organisms can enter the roots of cane without the aid of any mechanical injury whatsoever. I will designate these organisms not specifically but generically. I have found in these studies that a species of Pythium causes a root rot which has practically no color reaction in connection with the root, that is, the root remains white in aspect although completely infested, for 16 days. On the other hand, the Fusarium root rot which is quite common is one in which the rot is a red rot, a very distinct red rot which finally turns almost dark purple after three weeks. The Pythium root rot appears to be the most serious of the two, in that the organism appears to be able to penetrate not only the epidermis but also the stele. Fusarium, on the other hand, appears to be able to effect only the cortical areas except in the region just back from the root tip. I consider that the Fusarium is not nearly so dangerous as the Pythium rot. I consider really that fundamental studies of the reaction between the organisms found in the soil and that of the sugar cane should be conducted, especially usink single spore strains of the organisms and pure cultures of the cane plant, determining definitely whether the organisms can enter with or without mechanical injury. Do these organisms enter by mechanical pressure or by enzymic action causing a dissolution of the cell walls? I am now in the stage of determining this definitely.

Mr. Julius Matz: I would like to inform you that we have found in Porto Rico a very small larva (Sufetula grumalis) boring the roots, and that this has been identified for us by authorities in Washington. We do not know that this particular larva has appeared before.

Dr. Faris: I woul just like to mention in connection with root troubles that Mr. Stahl has in press a preliminary report on a grass-root mealybug (*Ripersia radicicola* Morrison) affecting sugar cane in Cuba and which will be published as Scientific Contributions No. 8 of the Tropical Plant Research Foundation. (Reprint from Journal of Economic Entomology, vol. 20, No. 2, pp. 392-399, April, 1927).

Dr. Brandes. Gentleman: I had not anticipated making any remarks on this subject because I would have preferred to be a listener. Mr. Johnston has, however, just asked me to speak about "anything new" on mosaic. Personally I have done very little in the last few years on the biology of mosaic on account of administrative duties, but I have followed with considerable interest the work of others. It seems to me that about the only contribution on this subject that has been made in the last four or five years that is very fundamental biologically has to do with the dissemination of mosaic in the fields, and it is reported by the investigator, Dr. P. J. Van Breemen, in the Archief, Meded., No. 18, pp. 513-43, 1926. It deals with the migration of *aphis maidis,* the insect vector of mosaic, and shows interesting correlations between these migrations and seasonal weather conditions. The careful recording of these flights of the insects under natural conditions constitutes one of the most interesting contributions we have had on this subject for a long time. Very early in the history of this disease in the New World several of the men who were investigating it made observations on the spread of mosaic and remarked on the apparent inconsistencies in the regional spread, the time spread, and the rapidity of spread. Prof. Earle and Mr. John A. Stevenson mentioned a number of things in 1918 and 1919. For instance, on the North Coast of Porto Rico in the vicinity of "Central Cambalache", there appeared to be a very small incidence of the disease on the coastal plain, but as soon as one went back through continuous fields of sugar cane into the little "pockets" where cane was planted in the limestone hills, there was an abundance of mosaic. Another observation of Prof. Earle's was with regard to the time or seasonal variation in the spread of mosaic as contrasted with this regional variation, and for illustration I think we can use conditions in the South West and South Coast of Porto Rico where it was noted that for long periods of time, up to a year, there was practically no advance of the disease into new territory. On the other hand, in approximately the same region, where Prof. Earle had collected and planted out a large number of varieties in a variety plot series, a high percentage of mosaic developed within a comparatively few weeks. The seed had been brought in from mosaic-free territory and the diseased plants of course represented new infections. We have had numerous illustrations of this variation in regional spread, seasonal spread and rapidity of spread during the whole course of the investigation of sugar cane mosaic in the New World and just recently valuable contributions have been made by some of the men engaged in practical sugar cane growing as the result of careful observations on the seasonal occurrence of mosaic in commercial cane plantations, (cf. J. Alfaro, The Planter and Sugar Manufacturer, p. 388-389, Nov. 14 1925.) A great deal of theorizing has been done to account for inconsistencies in the spread of mosaic even before it was proved to be an infectious disease and before insects were demonstrated to be concerned with the natural dissemination of the virus. It was early suspected that mosaic is a transmissible disease and field observations indicated that this was so before refined experimental methods were used to throw light on the problem. In 1919-20 a number of facts were conclusively demonstrated. These included proofs that would stand the closest scientifc scrutiny establishing conclusively that, (1) mosaic is infectious, (2) it is transmitted by *Aphis maidis,* and (3) a number of cultivated and wild grasses are subject to mosaic. With the establishing of these principles, we were no longer working in the dark as had been the case previously but many points remained to be cleared up, among the apparent inconsistencies in the natural dissemination of mosaic in the fields. Many people who published on the subject,

did so with the minimum of evidence and while some of them had made keen observations in their respective localities, there was an inclination to generalize as to the result of their individual experiments which, to my mind, is unjustifiable. The controversy which is now apparent in Cuba on the subject of spring-planted versus fall-planted cane is an illustration of the error in attempting to generalize in consequence of local experiences. To my mind, there is no reason for controversy in this matter as the contentions of both sides can be harmonized and made entirely consistent with the facts. These have been pretty well brought out by the careful experiments of Dr. Van Breemen. Prior to the publication of Van Breemen's results the correlation of rainfall and more rapid spread of mosaic was pretty well established. It was discovered, both in Porto Rico and Cuba, that the spreading seemed to be more rapid after the rainy season started and it was assumed at that time *Aphis maidis* was more active but there was no definite experimental evidence. Naturally I have seen these things myself in practically all regions where mosaic is a problem. In the winter of 1922-23 I was much impressed by the rapid spread of mosaic in the rainy season in bibit gardens near Malang, Java, as contrasted with the slow spread in the mill cane fields of the lowlands and brought this to the attention of Dr. van Harreveld, Dr. Kuyper and Dr. Jeswiet. I called attention also to the large *Aphis maidis* population in these bibit fields at Malang. It was in fact these observations that induced the Director of the Proefstation, Dr. van Harreveld, to carry these investigations further and Dr. Van Breemen has now given us the results of his careful experiments which clearly indicate the importance of weather in providing the necessary stimulus for the rapid increase and migration of *Aphis maidis*.

A theory that was brought forward at one time to account for the spread of mosaic was that weeding of the fields, thereby depriving the insect of its natural food, the preferred grasses, would result in the colonies of Aphids leaving the dry grass and migrating to the cane. I could not believe that this had more than an infinitesimal effect in increasing the number of new cases of mosaic as it obvious that weeding does not synchronize with conditions that lead to natural migrations of the insect in tremendous numbers. Weeding may play a small part in the spread of mosaic but it has been overemphasized. I have reported the abundant occurrence of *Aphis maidis* on the sugar cane plant in fields that were never weeded. This shows conclusively that such a thing as depriving the aphids of their food is not an essential factor in these migrations. When the grasses that serve as preferred food plants for the aphids are killed by cultivation, very few of the insects are able to get to the cane. It would only be by coincidence that many of the aphids in a colony would have wings at this time and the wingless ones prefer to stay on the wild grasses and die. I have even had the experience of clipping leaves from infected grasses with colonies of aphids and placing these leaves on healthy plants in order to attempt to transmit the disease with the result that many of the aphids would stay on the detached leaf that was its original home until they perished on the shriveled leaf in preference to traveling a fraction of an inch to the fresh leaves of the growing plant. In other words, it does not suit the convenience of the bulk of the aphids in a colony to be requested to move by the simple expedient of cutting down the wild grasses. It is true that in experimental work one can persuade the wingless aphids to move about quite actively by gently stroking them with a soft camel-hair brush and under natural field conditions also they may sometimes do so but as compared with nature's method in providing the inducement for migrtaions, cultiv-

ation plays a small part. To return to the subject of Van Breemen's researches, I have already related that he was directed to make an actual field study of migration of aphids and the staff at Pasoeroean deserves great credit for having initiated this work as they took little interest in this relationship prior to my visit in 1922. I was informed at that time that, while the scientists at that station admitted the possibility of insect transmission in view of my own experiments, they nevertheless were skeptical of any great practical significance in this fact. I was informed that *Aphis maidis* did not occur in the fields at Pasoeroean and, therefore, the occurrence of new cases of mosaic must be explained in some other way. Within a half hour of my arrival at the station, I collected speciments of *Aphis maidis* on grasses between the cane rows and in company with Dr. Kuyper found aphids abundant on the cane at Malang. When Van Breemen's experiments were finally under way the association of aphids with the dissemination of mosaic was confirmed to their satisfaction in a most remarkable way. He set up traps in the cane fields, consisting of double square frames between which were stretched pieces of decalcomania linen, both sides of which were covered with layers of vaseline. These traps were erected on bamboo poles so that they were considerably higher than the surrounding cane. The insects captured in these traps were examined daily and the number of individuals of Aphis maidis were reported. The results obtained indicated that winged individuals of Aphis maidis can occur in all seasons and that the quantity suddenly and materially increases shortly after the onset of the rainy season. This work was carried on at a number of places over the Island of Java where different weather conditions prevailed. The results are in agreement with direct observations on the occurrence of secondary infections in sugar cane and lead inevitably to the conclusion that Aphis maidis is in fact responsible for the bulk of secondary infections under natural conditions. Van Breemen states that the aphids do not persist when they alight on old cane but that they will start colonies on cane up to one or two meters in height. This is not in entire agreement with my own observations as I have found colonies on fairly large cane but I do believe that the evidence indicates that Aphis maidis prefers young cane. The practical significance of this work is that it affords an opportunity to take advantage to a certain extent of the fewer numbers of cases in the dry season and to cut seed cane and plant at this time. It certainly does not remove the necessity for intelligent roguing of seed plants as we may expect a certain proportion of mosaic plants at all seasons. I would recommend that any one interested in this subject obtain Dr. Van Breemen's article. It is well worth reading.

Mr. C. F. Stahl. I believe that I can more effectively present my data if I read a few of the statements that I have prepared. Some of these statements I might possibly be able to amplify. Meanwhile I have a few photographs illustrating the disease discussed in this paper.

A MOSAIC ON CORN

By C. F. Stahl

During the early part of the year 1925 a small corn plot in the garden at Ingenio Jobabo was kept under observation. The plants in this plot were heavily infested with *Peregrinus maidis* Ash. A conspicuous nottling or striping was noted on many of the plants which was at that time considered as a manifestation of sugar cane mosaic. None of the plants was infested with the corn aphis (*Aphis*

maidis Fitch). The affected plants were badly stunted and in many cases did not produce seed. Many attempts were made to transfer this disease to sugar cane by means of *Peregrinus maidis* but none of them were successful. The leafhoppers were able to survice for some time on the sugar cane but did not multiply.

Sugar cane mosaic was easily transferred from sugar cane to corn by means of the corn aphis (Aphis maidis) but the symptoms thus produced were very different from these on the corn in the plot. The mosaic produced experimentally by the corn aphids manifested itself as an indistinct mottling which resembled the pattern in sugar cane while the mosaic on the plants in the plot was characterized by a conspicuous striping. Lack of time and facilities made it impossible to carry the investigation any further in this locality.

Later when facilities were provided for work at Central Baragua the investigation of the relation of corn to sugar cane mosaic was continued. A plot of corn was planted and kept under observation. The plants became infested with *Peregrinus* maidis and the typical striping soon appeared on many of the plants. *Peregrinus maidis* transferred from these diseased plants to healthy ones grown under cover produced a similar striping on the covered plants. Sugar cane mosaic transferred to corn by means of the corn aphis produced a typical inconspicuous mottling similar to the mottling in sugar cane. The decided difference in the manifestation of the symptoms indicated that they were not produced by the same virus.

The symptoms produced on corn by the virus obtained from sugar cane by means of the corn aphis were, as has been noted, always a mottling which varied somewhat in intensity according to the variety of corn affected. Usually the mottling was very inconspicuous and disappeared to be produced by a fading out of the chlorophyll in the affected leaves. Often the symptoms were not visible except for a few days and in many cases the plants seemed to recuperate.

The symptoms produced by the virus transferred by means of the corn leafhopper have been found to vary considerably but it is not known at the present time that this variation is due to a different manifestation on the different varieties of corn. As a rule, the first visible symptoms are manifested by small elongated white specks usually on only one side of the midrib near the base of a young leaf. Gradually these specks elongate and some connect forming stripes running parallel to the midrib. As the disease advances the leaves become covered with slender interrupted stripes. In some cases these stripes fuse at the base of the leaf causing the chlorophyll to disappear. The variation in the appearance of the symptoms seems to be due to the intensity of the disease and is evidenced by the fineness or coarseness of the stripes and their tendency to fuse.

Although the plants growing in the plot were kept under constant observation it was not possible to detect the typical mottling of sugar cane mosaic on any of them in spite of the fac that the plants were growing under almost ideal conditions for the natural spread of this virus. In the light of the information at hand it seems probable that it would have been almost impossible to detect the symptoms of sugar cane mosaic on these plants. Over 50% of the plants were affected by the striping.

Transmission experiments which have been in progress for some time substantiate the theory that the disease found on corn is not the same as that found on sugar cane. Sugar cane mosaic has been easily transferred from sugar cane to corn and from corn to sugar cane by the corn aphis. The corn striping has been easily transferred from corn by means of the corn leafhopper. All attempts to transfer the sugar cane mosaic from corn to corn, from cane to corn or from corn

to cane with the corn leafhopper have been unsuccessful. All attempts to transfer the corn striping from corn to corn or corn to cane by means of the corn aphis have failed.

The results of our investigations so far may be summed up as follows: The prevalent type of mosaic in corn in Cuba seems to be that type which is manifested by a striping rather than by a mottling. This striping is readily transmitted from corn to corn by *Peregrinus maidis* Ash. The injury to the corn is severe. Sugar cane mosaic is transferred to corn by means of *Aphis maidis* but the symptons are much different from the striping and the injury appears to be less. All attempts to transfer the corn striping to sugar cane have failed so the disease is considered distinct from the sugar cane mosaic.

(A more detailed report on corn mosaic has been published by Mr. Stahl under the title "Corn Stripe Disease in Cuba not Identical with Sugar Cane Mosaic" as Bulletin No. 7, Tropical Plant Research Foundation, 1927).

Mr. Johnston: Dr. Storey also has a paper on the strains of the viruses affecting the Gramineae.

STRAINS OF THE VIRUSES AFFECTING THE GRAMINEAE

By Dr. H. H. Storey.

In the course of virus disease studies of sugar cane and related plants in South Africa, there have been observed what appear to be two separate strains of mosaic disease and two of streak disease.

The two supposed strains of mosaic have been separated upon differences in regional distribution and host range. In each case the symptoms are of similar character and typical of this disease. In the Coastal region of Natal the prevalent mosaic disease shows features not different from those of the disease occurring in other sugar growing regions. The range of affected plants includes sugar cane (except the variety Uba), maize (infrequently infected in the field and symptoms mild), *sorghum vulgare L. vars,* (But probably not "Kaffir" types) and various wild grasses.

The second supposed strains of mosaic have been found only in the Transvaal at about 3,000 – 5,000 feet altitude. The only known perennial host is *Sorghum arundinaceum Statf;* Maize and *Sorghum vulgare L. vars* (including "Kaffir") are susceptible and the symptoms well marked. This strain of mosaic appears not to infect sugar cane or at least produces no symptoms. Old established plots of cane in affected regions of the Transvaal are mosaic free; an experimental plot of several cane varieties has remained mosaic free, although adjacent to aphid-infected diseased sorghums and maize; while aphid-transmission experiments in Durban under conditions highly favorable to the transmission of the ordinary mosaic have consistently given negative results with the Transvaal mosaic.

Studies of the streak disease in Natal have also revealed what are thought to be strains of a virus specialised to separate hosts. Streak disease of maize, as normaluy found in the field, has been readily experimentally transferred to maize, using the leafhopper *Balclutha mbila Naude* as vector. Similarly streak as it occurs in Uba cane in the field has been transferred to Uba cane using the same vector. But it was found that the leafhoppers which had obtained the virus from the cane produc-

ed only a mild form of streak disease in maize, characterized by the small size and sparse distribution of the chlorotic spots. The severity of the disease produced by the virus which had originally come from cane was not modified by several passages through maize.

The leafhopper carrying the virus from maize always failed in many experiments to produce any permanent infections of Uba cane. Rarely a few characteristic spots appeared soon after inoculation, and from these spots leafhoppers obtained the virus and produced in maize the typical form of streak disease.

Dr. Brandes. The fact that Dr. Storey has been able to separate two strains of mosaic disease in addition to his streak disease is quite new to me. If he can confirm this it will be a contribution of the first magnitude.

Mr. Johnston: I understand that Mr. Crawley has prepared a paper on his experiences in the control of mosaic on various properties in which he is interested.

THE CONTROL OF THE MOSAIC DISTASE OF SUGAR CANE IN CUBA

By J. T. Crawley

(This paper was published in Facts About Sugar, June 4, 1927, pages 554-555.)

Mr. Crawley made the following additional remarks:

The colono system of growing cane makes the control of mosaic very difficult, and it would be impossible were this control dependent to any considerable extent in roguing. The colono will not consent to the pulling up and destroying of cane stools that they have secured with so much time and labor. Again the secondary spread in spring plant is usually so great that they easily and naturally become discouraged and begin to suspect either the good intentions or the competence of those who advise or direct them. Those of us who act in the latter capacity have to take conditions as we find them we cannot, even should we desire to do so, change the system under which cane is grown, and therefore, have to adopt measures that fit in with local conditions.

While I do not wish to appear as being opposed to roguing, yet I believe from a rather extensive experience that this method of mosaic control has been overemphasized. I have to change my recommendations as soon as one seems inadequate another gives more promise of success. At the present time we have adopted a radical change in our recommendations, and these in turn will be changed just as soon as better control measures are suggested. Seed selection is emphasized first of all, and it is recommended that the planting program be made a year in advance. Fields are to be selected from which seed is to be used and these fields are rogued systematically. All plantings of non-immune varieties are to be made if possible in the fall. There will be some mosaic in these plantings but if proper seed has been used this will be very small. Roguing now will depend on circumtances. If the land is good and the cane lasts for many years it is advisable to inspect the fields and pull up the diseased plants. If the land is poor and the cane lasts but two or three years it is doubtful if roguing is necessary, for the small amount of mosaic will not do a great deal of harm. When cane is planted in the spring either very carefully selected seed should be used, or immune varieties planted. At the present time the Uba is the only immune variety that is being planted and our experience with this variety is too recent to make any general recommendation. In the meantime those varieties that show resistance should be propagated and tested.

Where a plantation is so badly infected with mosaic as to make the securing of clean seed impossible it is advisable to purchase a small amount of clean seed from another district and raise mosaic-free cane for future plantings. As fast then as old fields quit producing profitably they can be planted with clean seed. This is a definite program, and although it requires a rather radical change from present methods it would seem that circumstances and experience suggest the advisability of its adoption.

Señor J. Alfaro: Manager of Central Portugalete.

Quiero decir antes de empezar que yo no soy ningún experto, soy un simple y modesto administrador de ingenio que ve los asuntos agrícolas. Cuando yo tomé la administración de ese Central la infección de mosaico era realmente muy importante. El sistema entonces en uso como recomendable como más eficiente era el sistema de arrancar los plantones enfermos y resembrarlos. Yo muchas veces he arrancado y he resembrado con semilla absolutamente sana. Sin embargo, a los cuarenta días los plantones que estaban al rededor tenían infección de mosaico y la tenían también los que yo había sembrado. Sin embargo, seguí recomendando a los colonos que siguieran extirpando el mosaico. Seleccionábamos la caña, y aunque muchas veces tenía apariencia de estar completamente sana tenía latente la enfermedad al salir nueva caña, pero después que los arrancábamos la segunda infección apenas mostraba mosaico y la tercera nada. La zona de "Portugalete" estaba prácticamente desolada por la enfermedad de las raíces por una parte y por otra el mosaico. Fomentamos la siembra de caña de frío y suspendimos la caña de primavera. Entonces observamos que eran sanos todos los cañaverales sembrados en frío. El señor Crawley empezó a investigar en los demás ingenios. Nosotros hemos hecho allí observaciones más curiosas todavía. (Drawing on blackboard). Este cañaveral fué sembrado en frío. Aquí había un cañaveral sembrado en primavera completamente lleno de mosaico. Aquí otro sembrado también de primavera completamente lleno de mosaico, y aquí había un campo de maíz. Todo esto aquí era una pequeña ribera llena de hierba de Para. Después de la segunda inspección uno estaba completamente libre de mosaico, el otro 100% de mosaico y el maíz lleno de aphis. Yo someto entonces este asunto para los que estudian la vida del aphids. No he encontrado otro método mejor que el sembrar caña de frío para combatir el mosaico.

Pregunta: ¿Qué clase de semilla han usado?

Contestación: La semilla que nosotros hemos usado aquí venía o de caña de frío o de caña de retoño.

Pregunta: ¿Qué clase de terreno?

Contestación: Seis clases de terreno. Terrenos que vienen explotándose desde el 1830. Terrenos colorados.

Yo estaba muy convencido de que arrancando los plantones podría terminar el problema, pero llegué a la convicción de que tendría que arrancar todo el Central. Es una campaña verdaderamente grande el arrancar tantos plantones enfermos. Después que se arrancó el 3% en un cañaveral le aseguré a los colonos que terminaría la infección, pero no fué así, porque después de haber arrancado ese 3% a los 40 días cuando se hizo la segunda inspección se tuvo que arrancar el 27%, y suponiendo que lo arrancara, a la tercera inspección tendría que arrancar todo el campo.

Pregunta: ¿Desyerbaban antes de arrancar?

Contestación: Sí.

Practicamos el cultivo por administración. Los colonos nuestros tienen órdenes imperativas para cultivar.

Pregunta: ¿Qué lluvia cayó durante todo el tiempo del experimento?

Contestación: Cincuenta y ocho pulgadas. Mientras se hizo el ensayo desde el día primero de Junio al treinta de Agosto habían caído veinte y siete pulgadas.

*Sr. Menéndez*s Yo he encontrado que yo he podido controlar mosaico en primavera, en medio tiempo y en frío con el sistema de selección de semillas y arrancando. Desearía presentar evidencia. No valdría la pena que yo tratase de dar estos datos en dos o tres minutos. Mi experiencia en la Isla de Cuba durante estas últimos dos o dos años y medio. Me parece que tengo evidencia suficiente para probar que el mosaico es controlado en la Isla de Cuba, por lo menos en la Provincia de Oriente, ya sea en plantaciones de primavera, de medio tiempo o de frío, siempre que la semilla se seleccione perfectamente bien, y después, repetidas veces, cada diez días. También es necesario de que la persona esté convencida ella misma de que puede hacerlo. Se necesita un trabajo muy delicado y vigoroso para controlar el mosaico. Si al empezar a controlar el mosaico usted admite que está vencido, el mosaico lo vence.

(TRANSLATION OF MR. ALFARO'S REMARKS)

Mr. Alfaro. Manager of Central "Portugalete".

First of all I would like to say that I am not an expert but simply an unassuming and modest administrator of a sugar mill who looks at things from an agricultural viewpoint. When I took over the administration of Portugalete, mosaic infection was a very important factor. The system then in practice and which was recommended as the most efficient, was the system of roguing diseased plants and replanting. I have many times rogued out and replanted with absolutely healthy seed. However, I found that after forty days the neighboring plants were infected with mosaic and so also were the ones I had planted. In spite of this, I still recommended to the colonos to continue to rogue. We selected the cane and although it had the appearance of being entirely healthy, it showed after starting to grow that it had the disease in a latent form; but after roguing the infected shoots; hardly any mosaic infection was shown in the second planting and none at all in the third. The zone of "Portugalete" was practically desolated by the disease of the roots on the one hand and mosaic on the other. We initiated the planting of frio cane and stopped that of primavera cane. We then observed that all the fields that had been planted to frio cane were healthy. Mr. Crawley started an investigation at other mills. There we made still more interesting observations. (Drawing on blackboard). This field of cane was planted frio. Here we had a field planted primavera which was completely affected with mosaic. Here we also had another field planted primavera completely affected with mosaic and here we had a field planted to corn. All of this section was a little ditch bank covered with Para grass. After the second inspection one field was completely free of mosaic, the other had 100% mosaic infection, and the corn was full of aphids. I submit this subject to those who are studying aphids. I am yet to find a better method than frio planting for combatting mosaic.

Question: What kind of seed have you used?

Answer: The seed which we used came from either frio or ratoon cane.

Question: What type of land?

Answer: Six different types of land. Lands which have been under cultivation since 1830. Red lands.

I was convinced that roguing the diseased plants might be a solution of the problem, but later was equally convinced that in order to do that I would have to pull out all the plants in the Central. It is certainly a big compaign to pull out so many diseased stools. After roguing 3% of diseased plants in a field of cane, I assured the colonos that the procedure would put an end to mosaic infection there, but this was not the case, as it became necessary to rogue 27%, in addition to the 3% mentioned, upon making a second inspection of the field 40 days later, and no doubt a third inspection would have required that all the plants in the field be pulled out.

Question: Did you weed before roguing?

Answer: Yes.

We practice cultivation by administration. Our colonos have strict orders to cultivate.

Question: Whas was the rainfall during the period of this experiment?

*Answer*s 58 inches. While the experiment was going on 27 inches of rain fell from the first of June to the 30th of August.

Sr. Menendez: I have found that I have been able to control mosaic in primavera, medio tiempo and frio by following out a system of seed selection and roguing. I would like to present evidence in this connection, but it would hardly be worth while to try to give the data in two or three minutes. My experience in the Island of Cuba has been during the last two or two an da half years. I believe I have sufficient evidence to prove that mosaic can be controlled in Cuba, at leats in Oriente Province, be it in primavera, medio tiempo, or frio plantings, providing the seed is carefully selected, and afterwards, repeatedly every ten days. It is also necessary that the individual undertaking this work be himself convinced that he can do it. If when you start out to control mosaic you admit that you are beeten, mosaic will beat you.

Dr. Brandes: This whole question of the practicable measures for control of mosaic in this island is so timely and the observations of Sr. Alfaro and Sr. Menendez Ramos are so valuable in this connection that I would suggest to both gentlemen the desirability of preparing abstracts of their remarks on experiences here to be incorporated in the minutes of these meetings.

Sr. Alfaro: I will prepare such an abstract.

Sr. Menendez Ramos: I can also let you have a statement of my experiences.

STATEMENT ON MOSAIC CONTROL BY SEÑOR J. ALFARO

Central Portugalete,
Palmira, Prov. de Santa Clara.
Cuba, March 20, 1927.

Sr. Elmer W. Brandes,
Habana.

Muy Sr. mío:

De acuerdo con los deseos de Ud., tengo el gusto de enviarle algunos estados, mostrando el resultado de las siembras de frío comparadas con las siembras de primavera, y ambas en relación con la enfermedad del "Mosaico".

En dichos estados (Tabla 1), observará Ud. que, en general, las siembras de frío arrojan siempre un porcentaje muy bajo de infección en las primeras inspec-

ciones, con la enorme ventaja de que, al final, se puede mantener el campo limpio de "mosaico" a un costo verdaderamente muy reducido, permitiendo de este modo obtenerse semilla limpia. En las siembras de primavera, a pesar de todos los arranques de plantones infestados que quieran hacerse, o se hagan, sucede todo lo contrario. Se observa al principio una infección relativamente pequeña y a pesar del constante arranque de los plantones infestados sigue en aumento la infección de tal modo y con tanta violencia que, llega un momento en que resulta prohibitivo el arranque, porque equivaldría a demoler por completo el cañaveral.

Los datos que enviamos a usted no son nada más que una parte de nuestra experiencia aquí, aun cuando esta ha sido, desde luego, más extensa según ya expliqué.

Yo no puedo desde luego, decir a usted ni a los señores técnicos cuál es la causa del resultado que nosotros estamos obteniendo y, por tanto, me limito simplemente a exponerle el efecto que obtenemos en nuestras plantaciones con las siembras de frío.

Sin embargo, en el boletín No. 18 de Java Archief, Medeelingen, el Sr. P. J. van Breemen, explica el resultado de sus experiencias dando una idea de la posibilidad de que al "Aphis maidis" tenga un período de activa emigración y otro de corta o posiblemente suspendida emigración. Si esto es cierto, podría fácilmente explicarse la causa cuyos efectos estamos nosotros observando.

Permítame copiar a continuación, una parte del artículo que el Profesor Earle publicó en la revista "Industrias de Cuba", en Marzo de 1926, Tomo V No. III.

> "Otra razón urgente para sembrar en Otoño o a principios del Invierno se debe al actual brote de la enfermedad del "mosiaco" en toda la isla. Esta enfermedad se esparce mediante infección secundaria, mucho más rápidamente en la caña sembrada en la primavera que en la sembrada en el otoño, de manera que su primer crecimiento ocurre en tiempo seco. No solamente es más susceptible la planta de crecimiento rápido en la primavera, *sino también los insectos que llevan los gérmenes son más abundantes en esa temporada*".

Nuestra misma observación, fué comprobada también por la Profesora M. J. ten Houte de Lange, cuando nos visitó a principios de 1926, llevándose un número considerable de nuestros reportes de observación para entregarlos al Sr. A. E. Mooyaarts en Soerabaia (Java).

Permítame también copiar a continuación lo que dice el Sr. P. W. Murray en la circular No. 6 de "Jamaica Department of Agriculture" (Microbiological Circular).

"Mosaic was first observed in Jamaica in 1920; the present report deals with methods and results in controlling the disease over the period 1923 – 25. Chief reliance is placed on roguing, but the efficiency of this method depends on the personal factor of the manager and the laborers. The most efficient and successful system, and the least expensive, is that of payment by result, the laborers being paid according to the number of diseased plants discovered and dug out; as the disease becomes reduced in amount it is necessary to raise the rate of pay".

"Experience has taught that after primary infection has been removed (Three roguings) it is not necessary to dig out the entire roots of new cases, only the affected canes in a stool and their immediate roots being removed. To be effective roguing should be frequent best at weekly intervals. Fields of very young cane may be rogued even when the infection is above 10 per cent, as the tops used for replanting come to maturity approximately with the others".

"In the parish of Westmoreland an interesting fact has emerged from the experience of the planters there in dealing with this disease. The practice in that parish of planting cane in the spring has been largely discontinued, as the planters found that the spring plants suffered severely from mosaic, while the infection on plants set out in the fall was almost negligible. By this fall planting of new fields much of the expense of roguing is saved".

Además, es muy curioso observar, y usted lo podrá ver en los estados que le envío, que aun sembrando de frío, hay diferencia en los resultados de la siembra, según sea usada semilla procedente de plantas de retoño, de plantas de primavera, o de plantas de frío. Por ejemplo:

Usando semilla procedente de plantas de primavera, bien seleccionada, el por ciento de infección de "mosaico" es de. . 0.46946%

Usando semilla procedente de plantas de retoño el por ciento de "mosaico" es de. 0.08289%

Usando semilla procedente de plantas de frío el por ciento de "mosaico" es de. 0.04052%

De manera que aun esta misma comparación, nos confirma nuestra observación y nos predispone en contra de las siembras de primavera.

Deseo también exponerle algunos de los casos curiosos que hemos observado y que son como sigue:

Siembras de Primavera

Estas siembras se han hecho seleccionando la semilla muy cuidadosamente, y se llevaron a cabo a fines del mes de Abril de 1926, en cañaverales sometidos al siguiente plan:

(A) Manteniendo las guardarrayas libres por completo de yerbas.

(B) Dejando crecer en las guardarrayas todas las yerbas usuales en ellas.

(C) Sembrando maíz al lado del cañveral.

En el caso (A) la infección secundaria ha llegado a cubrir la totalidad del campo (100 por 100).

En el caso (B) la infección secundaria ha alcanzado el 42.37%.

En el caso (C) la infección secundaria ha sido de 87.5%.

Siembras de Frío

Sometiendo estas siembras al mismo tratamiento, hemos obtenido en general muy escasa infección secundaria, y después de arrancados los pocos plantones infestados, los campos han continuado limpios de "Mosaico", teniendo en cuenta que en todo el maíz sembrado, como se explica en el caso (C) existían verdaderas colonias de "Aphis maidis".

Las experiencias de que vengo informando a Ud. han sido llevadas a cabo con análogos resultados a los expuestos, en los Centrales Hormiguero, San Agustín, Caracas, Pastora, San Francisco, Santa María, María Luisa, Carmita, La Vega, Parque Alto, Constancia y Narcisa.

Cuanto a los análisis de los jugos de las cañas sanas y las cañas enfermas, el resultado fué como sigue:

Cañas de plantas de primavera

Caña Limpia de "Mosaico".

	Brix	*Sacarosa*	*Pureza*	*Glucosa*
Muestra 1	17.03	13.98	82.02	1.38
„ 2	17.13	14.11	82.37	1.19
„ 3	17.73	14.54	82.00	1.31
„ 4	16.73	14.03	83.86	1.21
„ 5	16.73	13.48	80.57	1.58
Promedio.	17.07	14.02	82.16	1.33

Caña infestada de "mosaico".

Muestra 1	18.48	15.87	85.87	0.97
„ 2	18.38	15.76	85.74	1.09
„ 3	17.07	13.77	80.66	1.23
„ 4	18.38	15.50	84.33	1.03
„ 5	18.28	15.66	85.66	1.11
Promedio.	18.11	15.29	84.45	1.08

Por los análisis que anteceden puede apreciarse que los jugos de las cañas infestadas de "Mosaico" son más ricos en sacarosa que los jugos de las cañas sanas. Ello puede indicar, que la enfermedad en las plantas infestadas, ha precipitado su madurez; mientras que en las cañas sanas los jugos son más pobres pero la cantidad de glucosa es mayor, indicando que la planta continúa en su período de crecimiento sin haber llegado todavía a la madurez.

En cañas de segundo corte el resultado es muy distinto, según podrá usted apreciar por los siguientes análisis:

Plantas de Retoño

Cañas limpias de mosaico:

	Brix	*Sacarosa*	*Pureza*
Muestra 1	20.35	18.92	92.97
„ 2	20.35	18.99	93.31
„ 3	20.35	19.05	93.61
„ 4	20.25	19.05	94.07
„ 5	20.35	19.13	94.00
„ 6	20.25	19.05	94.07
„ 7	20.25	19.05	94.07
„ 8	20.45	19.09	93.34
„ 9	20.55	19.06	92.74
Promedio.	20.35	19.04	93.57

Cañas infestadas de Mosaico:

	Brix	*Sacarosa*	*Pureza*
Muestra 1	19.51	17.81	91.28
„ 2	19.61	17.92	91.38
„ 3	19.51	17.89	91.69
„ 4	19.48	17.93	92.04
„ 5	19.51	17.92	91.85
„ 6	19.51	17.92	91.85
„ 7	19.51	18.04	92.46
„ 8	19.68	17.92	91.05
„ 9	19.68	17.95	91.67
Promedio.	19.54	17.92	91.69

Como puede apreciarse ya existen pérdidas en los jugos de las cañas infestadas de "Mosaico" desde su segundo corte, y la importancia que para la industria tiene esta enfermedad es de tener muy presente.

Deseo hacer constar nuevamente que no soy hombre científico, sino simplemente un hombre de buena voluntad e interés. Hice pública mi observación, no con la vanidad egoista de recibir por ella un crédito al que no aspiro ni deseo, sino simplemente para que las personas interesadas en esta importante cuestión pudiesen obtener los mismos ligeros resultados que yo he obtenido. Deseo también repetir nuevamente que yo no soy contrario a la medida de arrancar los plantones infestados, por cuanto se ve por lo que expongo, que la practico. Pero sí es absurdo y antieconómico asegurar que arrancar el 60% de infección es, comercialmente hablando, de expléndidos resultados, según he oído repetir insistentemente en el Congreso, cuando se trató de esta enfermedad.

Selecciónese bien la semilla, pero para ello será necesario primero contar con cañaverales sanos. Abandónese por completo la siembra de primavera por ser agrícola y económicamente hablando contraria a la realidad e intensifíquese las siembras de frío. Después de esto, que los señores Entomólogos estudien cuidadosamente estos resultados, y estoy seguro que dentro de poco tiempo llegaremos a conclusiones más definitivas sobre esta importantísima materia, que nos permitirán erradicar esta enfermedad, con más facilidad y a un costo verdaderamente pequeño.

Si necesita usted cualquier otro dato en relación con este asunto tendré mucho gusto en facilitárselo a usted inmediatamente.

Permítame estrechar su mano y ofrecerme de Ud. muy atentamente,

(Firmado) *J. Alfaro.*

TRANSLATION

STATEMENT ON MOSAIC CONTROL BY SEÑOR J. ALFARO

Central Portugalete,
Palmira, Prov. de Santa Clara.
Cuba, March 20, 1927.

Dr. Elmer W. Brandes,
Habana.
Dear Sir:

In compliance with your request, I am pleased to send you tables showing results obtained from frio planting as compared with primavera planting, both bearing relation to mosaic disease.

(Table 1)

In said tables you will observe that, in general, frio plantings always show a very low percentage of infection in the first inspections, with the great advantage that, finally, it becomes possible to maintain the field free of mosaic at a comparatively low cost, and this will make is possible to obtain clean seed. In the case of primavera planting, however, no matter how many infested shoots one plans to take out or actually takes out, opposite results will be recorded. At first a comparatively low infection is observed, but it so happens that not withstanding continuous roguing the infection continues to augment in such a manner and with such intensity, that a time will come when roguing is prohibitive inasmuch as it would amount to practically destroying the entire field of cane.

The data which we have sent you are nothing more than a part of our experience, here, although it has been, of course, more extensive, as I have already explained.

I cannot tell you, nor the Technical men, what is the cause of the results which we are obtaining and, therefore, I confine myself to simply presenting these results obtained in our fields with frio plantings.

However, in Bulletin No. 18 of Java Archief, Medeelingen, Mr. P. J. van Breemen, in explaining the result of his experiences, gives an idea of the possibility that the "aphis maidis" may have a period of active emigration and another period when this emigration is reduced or possibly stopped entirely. If this is true, it would be easy perhaps to explain the cause of the effects which we are observing.

Permit me to make the following copy of a part of the article which Prof. F. S. Earle published in the revista "Industrias de Cuba", March 1926, volume V No. III.

> "Another urgent reason to plant in the fall or at the beginning of winter is due to the present outbreak of the mosaic disease in the whole island. This disease spreads by secondary infection, much more rapidly in cane planted in the spring than in cane planted in the autumn, as its first growth occurs in dry weather. It is not only that the plant of rapid growth in the spring is more susceptible, but *also the insects which carry the virus are more abundant at that time*".

Our first observation was also confirmed by Prof. M. J. ten Houte de Lange, when she visited us early in 1926. She took along a considerable number of our reports of investigations to deliver same to Mr. A. E. Mooyaarts at Soerabaia, (Java).

Permit me also to make the following copy of what Mr. P. W. Murray says in circular No. 6 of "Jamaica Department of Agriculture" (Microbiological Circular).

"Moreover, it is very interesting to observe, and you will be able to see this from the tables which I am sending you, the difference in the results of planting depending on whether the seed used comes from ratoon plant, primavera or frio. For example:

Using seed from primavera plants, well selected, the percentage of infection of mosaic is.	0.46946%
Using seed from ratoon plant, the percentage of mosaic infection is	0.08289%
Using seed from frio plant, the percentage of mosaic infection is	0.04052%

Therefore, even these very comparisons confirm our observation and prejudice us against primavera plantings.

I wish also to point out to the following interesting cases which have come under our observation:

Spring Plantings

These plantings were made after a careful seed selection in the latter part of April, 1926, in fields of cane subjected to the following plan:

(A) Maintaining the guardarrayas entirely free from grasses.

(B) Allowing grasses to grow naturally in the guardarrayas.

(C) Planting corn alongside fields of cane.

In case (A) the secondary infection covered the entire field (100 per cent).

In case (B) the secondary infection was 42.37%.

In Case (C) the secondary infection was 87. 5 %.

Frio Plantings

By subjecting these plantings to the same plan, we have had in general very little secondary infection, and after roguing the few infested shoots, the fields have continued free of mosaic, taking into consideration that in the planted corn, as explained in case (C), there were real colonies of *Aphis maidis*.

The experiences about which I have been speaking to you, have been carried out with similar results at Centrales Hormiguero, San Agustin, Caracas, Pastora, San Francisco, Santa María, María Luisa, Carmita, La Vega, Parque Alto, Constancia y Narcisa.

In regard to the analyses of the juices of healthy canes and diseased canes, the results have been as follows:

Canes of Spring Plantings

Cane free of mosaic:

	Brix	*Sucrose*	*Purity*	*Glucose*
Sample 1	17.03	13.98	82.02	1.38
„ 2	17.13	14.11	82.37	1.19
„ 3	17.73	14.54	82.00	1.31
„ 4	16.73	14.03	83.86	1.21
„ 5	16.73	13.48	80.57	1.58
Average	17.07	14.02	82.16	1.33

Cane affected with mosaic.

Sample 1	18.48	15.87	85.87	0.97
„ 2	18.38	15.76	85.74	1.09
„ 3	17.07	13.77	80.66	1.23
„ 4	18.38	15.50	84.33	1.03
„ 5	18.28	15.66	85.66	1.11
Average	18.11	15.29	84.45	1.08

By the preceeding analyses it can be seen that the juices of canes affected with mosaic are richer in sucrose than the juices of healthy canes. This may indicate that the disease in the infected plants has hastened their maturity. In the healthy plants,

however, the juices are poorer but the amount of glucose is larger, which shows that the plant is still in its period of growth and has not as yet reacher maturity.

In canes of second cutting the result is very different, as you will be able to see from the following analyses:

Ratoon Plants

	Brix	*Sucrose*	*Purity*
Sample 1	20.35	18.92	92.97
„ 2	20.35	18.99	93.31
„ 3	20.35	19.05	93.61
„ 4	20.25	19.05	94.07
„ 5	20.35	19.13	94.00
„ 6	20.25	19.05	94.07
„ 7	20.25	19.05	94.07
„ 8	20.45	19.09	93.34
„ 9	20.55	19.06	92.74
Average.	20.35	19.04	93.57

Canes affected with mosaic:

Sample 1	19.51	17.81	91.28
„ 2	19.61	17.92	91.38
„ 3	19.51	17.89	91.69
„ 4	19.48	17.93	92.04
„ 5	19.51	17.92	91.85
„ 6	19.51	17.92	91.85
„ 7	19.51	18.04	92.46
„ 8	19.68	17.92	91.05
„ 9	19.68	17.95	91.67
Average	19.54	17.92	91.69

It can be seen that there are already losses in the juices of canes infected with mosaic after the second cutting, and the importance of this disease to the industry is a matter which must be taken into consideration.

I wish to state again that I am not a scientist but simply a practical man who is vitally interested in this problem. I published my observations not with the selfish purpose of receiving credit for same but with the idea in mind that those interested in this important question might obtain the same trifling results that I have obtained. I also wish to again repeat that I am not opposed to the practice of roguing infected shoots, as it can well be gathered from my statements that I practice roguing. But it certainly is absurd and uneconomical to claim that roguing 60% of the infection will give, commercially speaking, wonderful results, as I have heard repeatedly in this Congress when this disease was discussed.

Select carefully the seed, but in order to do this it will first be necessary to have healthy cane fields. Discontinue entirely spring plantings on account of it being, agriculturally and economically speaking, contrary to best practice, and confine yourself to frio plantings. Afther this, let the entomologist study carefully these results and I am sure that within a short time we will arrive at more definite conclusions

regarding this very important question, which will make it possible to eradicate this disease with more facility and at a greatly reduced cost.

If you need any further data concerning this matter, I will be glad to furnish you with same at once.

(Signed) *J. Alfaro.*

STATEMENT ON MOSAIC BY SEÑOR R. MENENDEZ RAMOS SUGAR ESTATES OF ORIENTE, INC. CENTRAL PALMA.

Oriente, Cuba.

March 23, 1927.

Dr. W. E. Brandes,
Hotel Florida,
Habana.

Dear Dr. Brandes:

This is to accompany the short article which you requested condensing the data presented by me at our recent meeting. All tables but one have been left out as recommended by you.

Hoping that this will be satisfactory, and with best wishes for your stay in Cuba, I beg to remain.

Very sincerely yours,

R. Menéndez Ramos.

THE CONTROL OF SUGAR CANE MOSAIC IN THE WEST INDIES

By R. Menéndez Ramos

(This paper was published in The Reference Book of the Sugar Industry of the World, July, 1927).

March 17, 1927, 2. P. M.

Mr. J. R. Johnston in the Chair.

(Continuation of discussion on Control of Sugar Cane Mosaic)

Mr. F. S. Earle: The variation in spread is due to seasonal differences and the chance for rapid spread of mosaic is better in the spring in most of Cuba. In my experience at Santa Rita, Porto Rico, the spread was more rapid in October, at which time the planting was accompanied by heavy rainfall.

Sr. Matacena: I wish to state that my experience is that we have rogued at all times of the year and the number of new cases was much greater during the rains but diminished as the rains tapered off.

Dr. Faris: I have the following data bearing upon the relative spread of mosaic in spring and fall plant cane in Eastern Cuba.

No. 1 Replants	Acres 6 × 6	Acres 6 × 3	No diseased plants	% Infected
Fall 1926—A	2654.72		2439	.1054
Spring 1926—B	1303.84		1664	.1275
Fall 1927—A	809.72	685.89	3366	.0789
Spring 1927—B	344.44	304.69	1562	.1354
Average infection in spring replants (1926—B & 1927—B)				.1181%
Average infection in fall replants (1926—A & 1927—B)				.1008%

Increase in spring planting .0173 or 17.1% over Fall.

	Class	Area in acres	% Infection
No. 2.	Fall 1925	188.241	.040
	Spring 1926	145.679	.423
No. 3.	Fall 1925	103.839	.834
	Spring 1926	167.119	.833
No. 4.	Fall 1925	135.916	1.715
	Spring 1926	109.276	1.953

As is indicated from these data, in the case of one planting there was an increase of 17.10% in the spring planting as compared with the Fall planting. In another colonia, case No. 2, there was a very great increase in mosaic in the spring planting. In case No. 3 the highest infection was in the Fall planting. In case No. 4 the infection was slightly higher in the spring planting. These figures are from rather extensive areas. An experimental planting was made last October in which mosaic-clean seed was planted alongside fields of mosaiced Cristalina cane. There were a total of 1,170 plants, 117 of which were mosaiced in February 1927, that is a secondary infection of 9–3/10%. It seems to me that these figures indicate a very close relation between rainfall and the spread of mosaic in plant cane. Since the rainfall is less during the growing season immediately following the planting of frio cane in most parts of Cuba, the planting of frio cane would seem to be an advantage in the control of mosaic in such areas. However, this is only one means and as the data submitted indicate, cannot be depended upon entirely to control mosaic. The conditions vary so much in the Island of Cuba that we cannot generalize on so important a matter as the field control of mosaic. Some areas have very little mosaic although no means have been taken to prevent its spread. Others have considerable mosaic which has been held in check by the planting of clean seed and roguing plant cane. There are other areas where the spread is so rapid and the fields have such a very high percentage of mosaic that it does not seem practical to attempt to control the further spread by roguing. In these areas we are looking for relief by planting canes which are resistant to mosaic.

Mr. Menéndez Ramos: In the Porto Rican Experiment Station literature the season variation and association with rain is brought out. I wish to point out that there are three possible ways of controlling mosaic; No. 1 Plant immune varieties such as Uba; No. 2 Plant resistant varieties; No. 3 Plant susceptible varieties and rogue. I wish to give my experience in Colonia Mibia at Central Palma, Oriente, Cuba, where we planted Santa Cruz 12 (4) and B. H. 10 (12) canes and rogued

out to the amount of 12 to 15%. From these plantings we distributed 2,000 tons of seed cane and kept records of the fields to which they were distributed. This cane came up to I to 2% mosaiced. I wish to cite the records I have here which I believe show the practicability of roguing of cane plant at any time of the year as a means of protection against mosaic. The first roguing should be done when the cane is 1 to 1½ months old. The roguing should be done often, persistently and throughly or not at all. If the work is not through, it is a failure.

Sr. Alfaro: What is the cost of this roguing?

Sr. Menéndez: $50.00 to $200.00 per caballeria or an average of about $100.00.

Sr. Alfaro: In the second year, are the fields free of mosaic?

Sr. Menéndez: They are practically free, ½ to 2% in ratoons. I continue to rogue in seed field ratoons but not in general fields. I wish to submit this data giving the amount of roguing in spring plants. Planting made June 4, first roguing July 20, 2nd, August 20, B 6308 2% in July 20, 4% August 20, POJ 2725, 2 in July 20, none in August 20. Cristalina 3 in July 20, 8 August 20. B H 10 (12) 5 in July 20, 6 August 20. S. C. 12 (4) 2 in July 20, 8% August 20. By roguing throughly we closed the fields with little mosaic and we feel that mosaic can be controlled in this way in spring cane. It is easier to keep fall plant cane free from mosaic as we are aided by the dry weather. The same is true of spring plant cane if the planting is followed by dry weather. In order to do the roguing we send men thru the fields with small bags of seed over the shoulders and as they take out a mosaic plant, they immediately supply with seed from the bag. My experience boils down to (1) That there is no seed in an infected area completely free of mosaic; (2) mosaic can be controlled in spring plantings as well as in fall plantings, but the control is easier in fall plantings on account of the rainfall conditions.

Sr. Matacena: I would like to ask if mosaic spread under irrigation conditions in Hawaii is as bad as spread in Cuba.

Dr. Brandes answered that under irrigation in the Hawaiian Islands the spread of mosaic is not so rapid as under more humid conditions in the same region, such as the northeast coast of the Island of Hawaii. In the latter region where the rainfall is between 100 and 200 inches per annum on some plantations it has been necesary to change varieties in order to control mosaic, but roguing has been successful under irrigation in the more arid regions.

Mr. Menendez: I wish to state that the same observations are confirmed by my experience in Santo Domingo and that I am 100% optimistic about the success of the seed plot selection and roguing method for control of mosaic in both Cuba and Santo Domingo.

Mr. Molino: If Sr. Alfaro's work is accepted, it would do away with the work of our most important investigators. In the case given by Sr. Alfaro where the frio plant cane was surrounded by spring cane, I do not see how the mosaic could have occurred only in the spring cane.

Mr. Alfaro: The frio cane was completely free of mosaic.

Mr. Molino: I believe Sr. Alfaro's results conflict with previous work.

Mr. Johnston: In what way do you think they are conflicting?

Mr. Molino: They conflict with reports on the spread of mosaic in weedy fields infected with mosaic, etc.

Mr. Menendez: Before going ahead I wish to state that Mr. Molino closed in 3,300 acres of cane roguing every 12 or 15 days, that there was 1% of primary infection and only 6 or 7% at the most taken out.

I wish to state that with the best selection some mosaic can be found, that we get primary infection in all plantings, that in most cases most of the trouble is in the spring plant cane rather than in the fall, that the spread of mosaic is more rapid with the rainfall. I recommend that the cane be rogued early, timely and thoroughly, and clean cultivation.

Data from Central Fajardo in Porto Rico shows that 1.21% was rogued out in fall cane, .7% in spring cane and 1.59% in ratoon cane. Here they have absolutely effected control by roguing and have succeeded in eradicating mosaic in this way.

Mr. Matz: I wish to call Sr. Menendez' attention to the fact that Central Fajardo in Porto Rico has never had enough mosaic to talk about and there was very little there from the start, so he is overstating the case to attribute the increased yields to the control of mosaic.

Dr. Edgerton: I wish to refer to some work which we have been carrying on in Louisiana with our Louisiana purple cane. We noticed individual plants with mosaic which had less severe symptoms than others; we selected these and planted in plots. Our later selections also included plants apparently resistant to root rot conditions. For the mosaic we selected mosaic plants whose leaves were without the secondary white necrotic areas. The lantern slides indicate the results of these selections in which we obtained a marked increase in yield with 4 years of selection. I have no explanation for this phenomenon.

Mr. Bonazzi: I have been doing some work upon the artificial inocoluation of cane with mosaic. We also find a very striking difference in acidity of the juices in various parts of the plant.

Sr. Lopez Dominguez: Sr. Bonazzi has a new and effective method for artificial inoculation of the plants.

Sr. Bonazzi: We bore a hole at the base of the bud with an ordinary cork borer and in this place apical bud tissue from infected cane. The sticks are then planted and I get as high as 80% infection in the new sprouts. The varieties have a very great difference in response to this form of inoculation. I have noted a high content or carbon dioxide gas in cane and this along with a difference in acid may have an effect on my failure to secure 100% infection. C 35, D 74, and Kavangire are among the varieties used in these experiments.

Sr. Alfaro: Referring to Van Breemen's work, this would seem to offer an explanation in our zone. In primavera cane at the first roguing we dig out 4 to 5%. In 40 days 20%.

Sr. Menendez: This indicates that we have to rogue often.

Sr. Alfaro: We have not been able to control mosaic by roguing, our infection reaching 72% in a single season.

Dr. Brandes: This matter of seasonal spread of mosaic is very intriguing. I prefer to think of it in terms of the mechanics of dissemination or, in other words, to try to visualize the actual passage of the virus from diseased to healthy plants through the medium of the known carrier, *Aphis maidis*. It is apparent that a tremendous amount of detailed observations must be made in every locality in order to apply to practical purposes the results of research on the problem of natural dissemination. I am open to conviction as to whether there are other means of natural dissemination than the known vector, *Aphis maidis*. However, with our increased knowledge of the habits and migrations of this insect we do not appear to have the same necessity for seeking further for an explanation of rapid dissemination in nature To repeat the work of Van Breemen in other localities would be very illuminating

and this would be a very fertile field of endeavour here in Cuba. Clean cultivation will not eliminate mosaic, although it might materially reduce the amount under certain conditions. The fact that it is not more effective is due to the ability on the part of *Aphis maidis* to fly for considerable distances. This was impressed upon me by the following incident. Several years ago when I was crossing lake Okeechobee, in Southern Florida, and was about two miles from shore, I suddenly found my white linen suit covered with aphids. It proved to be a flight of aphis maidis. These tiny insects are probably not strong fliers and it is questionable whether they could make much headway if impeded by the wind. On the other hand, it is probable that they are carried for considerable distances by the wind. Hence the spread of mosaic by *Aphis maidis* will normally follow the direction of prevailing winds. These facts naturally do not constitute an argument against clean cultivation, the benefits of which need not be dwelt upon here, but it does indicate that in connection with the control of mosaic clean cultivation may have been over-emphasized. The correlation between grassy fields and a high percentage of mosaic, which is so often noted, may in reality be an indirect relationship, the abundance of grass being due to excessive rainfall. Such conditions favor the increase of the Aphis maidis population in the cane fields but they also favor such an increase on uncultivated lands. The relationship between weather conditions, development of food plants of Aphis maidis, including the wild grasses, and the fluctuation in numbers of *Aphis maidis,* is a complicated one but considerable light has been shed upon it in recent years.

Dr. Edgerton's work on selection of disease tolerating strains of D-74 and other varieties of sugar cane leads me to think of the possibility of the existence of distinct strains of mosaic in sugar cane. We have found more than one strain of mosaic within the Gramineae, for example, mosaic of the edible bamboo which can be transmitted to other bamboo plants but which we were not able to transmit to other species of grasses.

Mr. Stahl: Was *Aphis maidis* the transmitter?

Dr. Brandes: No, but natural transmission was observed in the detention greenhouse of the Federal Horticultural Board where these plants were being held in quarantine, the agency being unknown. More recently, evidence of the existence of other virus diseases in the grass family has accumulated. In 1922, in Hawaii, I saw Dr. L. O. Kunkel's corn mosaic and informed him that, while he undoubtedly had mosaic in the corn, it was complicated by some other disease. His disease was very different from our sugar cane mosaic in corn, being characterized by extreme dwarfing and etiolated stripes running the entire length of the leaves. Dr. William H. Weston, who had seen this condition in corn in Hawaii, reported a similar condition in the Island of Guam in 1917. Although it was not recognized as an infectious disease by Weston, the identity with the disease described later by Kunkel in Hawaii is unquestioned. I have not yet seen the corn disease reported by Mr. Stahl but from his description and from the fact that it is transmitted by *Peregrinus maidis,* I suspect that it also is identical with the Hawaiian trouble. Incidentally, it might be disastrous if this Hawaiian corn disease were introduced into the United States as the vector, *Peregrinus maidis,* is widely distributed in the corn belt. Kunkel found that he could transfer this disease from corn to corn with *Peregrinus maidis* but not to sugar cane with this insect. He could readily transmit the sugar cane mosaic to cane by means of *Aphis maidis.* In the Office of Sugar Plants at Washington, we attempted to transmit the sugar cane mosaic in corn to healthy corn plants by means of *Peregrinus maidis* but got only negative results in three large scale experiments

during the summer and Fall of 1923. This, together with the decided difference in symptoms led me to believe more strongly that Kunkel was dealing with a complication of virus diseases and just recently Kunkel has come to discriminate betweeen the two maladies. In addition to the above mentioned virus diseases in the Gramineae, we have of course the streak disease in Uba cane and in corn reported by Mr. Storey in Natal which is transmitted by still another species of leafhopper and is obviously distinct from any of the aforementioned virus diseases. There may be a multitude of mosaics in the grasses and it will require a great deal of detailed and painstaking study to separate them.

Recovery is another phenomenon of considerable interest in connection with grass mosaic. We first said that once a plant was affected it was always affected. This may be true in the case of certain varieties of cane. Undoubted cases of recovery have since been observed, however, and it is of special interest to note that this has occurred in varieties of the "noble" group of canes. While in Hawaii, in 1922, my attention was directed to Badila seedlings in which the leaves from the upper joints were apparently healthy, although the plants were originally diseased. Cuttings from these upper joints gave rise to healthy new plants. Just how the virus was screened out during the development of the upper joints is not known but it may be a case analogous to that of tobacco in which Dr. H. A. Allard has demonstrated the tobacco mosaic to be filtered out in thefloral organs. Tobacco mosaic, as you know, is not transmitted through the seeds. The disease was thought to be systemic, that is, that the virus permeated every part of the plant. In a series of very careful experiments Allard proved that the virus could be recovered from all parts of the plant, excepting the ovule. Apparently the virus was filtered out in the tissues of the placenta. It may have been a similar filtering process accounting for the production of mosaic free joints at the tip of diseased cane plants of certain varieties. This apparent recovery is a very significant thing at any rate and supports the hope that there may be such a thing as real immunity in varieties of the noble group. This phenomenon of recovery must be distinguished from the tolerance to mosaic in the case of selected individuals which was brought to your attention by Dr. Edgerton. An explanation for Dr. Edgerton's results is rather difficult . It might be that he has a changed condition of the virus rather than of the host plant; in other words, an attenuated virus. There may be even a distinct strain of virus. The theory which is most likely to be advanced because it apparently is more familiar, is that the tolerant plants represent a mutation, or bud sport, which is more resistant to the sugar cane mosaic than the parent stock. I am inclined to be skeptical of the mutation theory to account for the many variations seen in individual stools of cane. Without reference to the case under discussion this mutation theory has been overemphasized in connection with the amelioration of sugar cane varieties. The Dutch workers in Java tried for many years to ascertain whether they could breed better cane from selected hills within a variety and conversely whether they could breed inferior strains by selecting the poorer hills of the same variety. They noted that after several years there was always a tendency to return to the normal and concluded that selection within a clone was without permanent hereditary results. While we do have authentic cases of mutation such as the color sports, they are exceedingly rare and I doubt the practicability of rapid improvement of sugar cane varieties by attempted selection of true mutations. The chances for rapid improvement are much greater when the chromosones are shaken up by hybridization.

Dr. Jeswiet: This agrees with my observation also.

Mr. Earle: This subject is very intriguing. The evidence seems that this (referring to Dr. Edgerton's selections of mosaic resistant cane) can hardly be a bud sport or mutation but we are thrown back on mass selection.

Dr. Edgerton: I do not think it is a bud sport.

Dr. Brandes: I do not think we ought to pass such an important matter as the control of mosaic until we touch upon the ideal control measure which is the use of resistant varieties. This is a method of control which would eliminate expenditure of money and relieve the planter of even thinking about mosaic. In other words, a "fool proof" method is a consummation devoutedly to be wished. Not only in the case of mosaic but with other major diseases of the cane plant, we find evidence of resistance and immunity on every hand if we but take the trouble to look for it. Perhaps it is appropriate to discuss at this time the general broad topic of resistance to diseases in the different species of genus Saccharum. We have observed that with few exceptions sugar cane varieties classified according to their resistance or susceptibility to disease fall within groups identical with varieties classified according to their morphological characteristics. In other words, there is a consistent tolerance of certain diseases in the case of varieties with the same blood and conversely nearly related varieties are usually susceptible to the same disease. There are of course more varieties in groups of canes resulting from crosses between two species but even here the tendency is for similar reaction to disease. To be specific, in *Saccharum spontaneum* we have a species immune to mosaic as far as available records go. On the same grounds it is immune to sereh. If not immune, it is very resistant to root diseases. It has an exceedingly vigorous and abundant root system which is capable of regenerating itself when attacked by fungi or predacious animals. This species, however, is severely attacked by a downy mildew, several leaf spots and the cane smut, *Ustilago sacchari.* The next most primitive species, *saccharum barberi,* also has a vigorous and well developed root system compared with the mass of the above-ground parts and consequently does not auffer from root troubles as do the noble canes. It is probably the most susceptible species to mosaic but in general varieties of this species are not so severely injured by mosaic. In other words, they are tolerant. It is on this account that hybrids such as 36, 213, and 234 P. O. J. which contain the blood of *Saccharum barberi,* show up to advantage in comparison with the equally susceptible but severely injured noble varieties. The varieties of *Saccharum sinense,* in common with those of the two foregoing species, have luxuriantly developed root systems and are not noticeably injured by root troubles. In regard to mosaic, the varieties of this group do not react uniformly, some being susceptible and some apparently immune. The susceptible ones are, however, the most tolerant to the effects of mosaic of all groups observed. The group as a whole is very susceptible to cane smut; in great contract to the varieties of the noble group rarely attacked by this disease. We now come to a consideration of the varieties of *Saccharum officinarum* which may be characterized in general as the most susceptible of all. Root diseases, local leafspotted diseases, rots and virus diseases are able to overcome the resistance of *Saccharum officinarum* with little difficulty. Even in this group, however, we find occasional evidences of resistance such as the aforementioned rare occurrence of smut in the noble canes. Also recovery from mosaic has been noted and there is a considerable *range,* of tolerance among the different varieties of the group. When it becomes necessary to consider the practical problem of control of disease in sugar cane, one who knows these characteristics have a big advantage in producing by hybridization commercial canes resistant to the various diseases

Although it has not always been done with the special object of securing immunity or resistance to disease the hybridization carried on by different experiment stations, and particularly by the one at Pasoeroean, has demonstrated the wonderful practical advantages that may be secured by this means. This fundmental work which has meant so much to the sugar industry there, is of course particularly applicable to Javan conditions and we cannot trust to the solution of local problems by including their improved varieties. It is true that many of them might be superior to the varieties in general cultivation here but this would be a matter of chance. Local experiments to develop varieties capable of withstanding the unfavorable environmental conditions here would be exceedingly advantageous.

Some illustrations of the success of this method in fighting sugar cane diseases may not be out of place. In Java when the industry was threatened with extinction on account of sereh, attention was directed to breeding for resistance and many hybrids with *Saccharum barberi* blood were produced capable of growing in spite of sereh. Together with the observations that the disease was not severe in high altitudes and adoption of the practice of growing seed cane in mountain gardens, this use of tolerant varieties saved the cane industry there from complete extinction. Another illustration is the substitution of Kavangire cane for Rayada and Cristalina in western Porto Rico. Mr. Earle was the first in the western hemisphere to point out immunity to mosaic in this variety. It had previously been observed in Argentina that Kavangire and the tolerant P. O. J. varieties thrived better than the Creole canes but it was not suspected there that an infectious disease was involved until this fact had been pointed out in Porto Rico. Mr. Earle noted that Kavangire cane was free from mosaic in the variety plots of the Experiment Station at Mayagüez, Porto Rico. By importing a few tons of seed cane from Argentina, the planters, recognizing the value of this observation, increased the plantings of Kavangire from these few tons to 60,000 acres in three years time. In Louisiana a still more complete change of varieties to control mosaic is taking place. Several of the Chunnee–Cheribon hybrids are replacing the D 74 and Purple varieties so rapidly that the latter will probably be only a memory in some areas within a short time. This is what I referred to as the ideal method of controlling mosaic but it must be remembered that in the eyes of commercial planters it sometimes falls short of expectations. The new varieties may have undesirable features such as slenderness of stalk, tenaciously clasping leaf sheaths or other features objectionable to th planters. This, plus, the reluctance to make any kind of change which is common to agriculturists everywhere, makes them sigh for the esteemed varieties of the good old days. While the immune varieties, or tolerant varieties, now available are to my mind far superior, under present conditions of disease saturation, to the noble canes formerly grown, some of these objections are valid and to meet them there yet remains the possibility of immunity within the species *Saccharum spontaneum*. I believe we are not justified in complacently accepting these more or less primitive cane types as a substitute until a more rigid examination has been made of what nature may offer. It has been mentioned before at these meetings that there is evidence of tolerance and even of immunity to mosaic in the noble varieties. This is a phase of the mosaic problem that I think should be followed up with the greatest energy. If I may be permitted, I should like to take time to outline a proposed research into this matter and to offer evidence suporting the theory upon which the investigation will be based. In addition to other evidences of immunity to mosaic in the noble we have specifically the case of recovery in the Badila seedlings already mentioned. Badila is a variety

which was brought to Queensland by the Australian botanist Tryon in the late nineties from the island of New Guinea. Presuming that immunity may exist, the question arises as to where we should seek for it with the greatest expectation of being successful in the seareh. After giving considerable thought to the question, I have decided that it should be sought among the naturally produced seedlings in Melanesia. According to the best informed authorities with whom I have discussed the matter, this region is the home of *Saccharum officinarum*. Evidence to support this fact is not wanting but to discuss it in detail here would require too much time. The great variety of sugar cane types or varieties, particularly the striped and highly colored ones, that abound in this region where they are used by the very primitive Aborigines for food, testifies to the natural occurrence of seedlings in great numbers. The savage men who dwell in these islands must have a great diversity of forms to choose from and their delight in highly colored objects is well illustrated in the kinds that have been picked out for growing in the cane patches maintained by the villages. Each village generally has a variety of cane peculiar to itself. We have also evidence that a number of the major diseases of sugar cane, including mosaic, exists in this region. By the fragmentary evidence contained in narratives of explorers, by correspondence with men who have visited New Guinea and by personal contact with some of them, I have ascertained that in all probability mosaic, leafscald, downy mildew, Fiji disease and cane smut are all found in New Guinea. To sum up and correlate the above mentioned facts we have the evidence of immunity in the noble canes, the evidence that they are indigenous in Melanesia, the evidence that sugar cane is there produced regularly and abundantly by seeds and the evidence of the ocurrence of many of the major sugar cane diseases. What could be more probable than the operation of the law of natural selection under this set of conditions and the survival of seedling varieties resistant to disease? It would seem a worthy enterprise to send an expedition to these Islands in order to secure collections of cane varieties for disease resistance. I am glad to say that the last Congress appropriated a sum of money for the purpose of selecting and breeding better varieties of sugar cane resistant to mosaic and that this can be used for an exploration of New Guinea. Such an expedition would of course require very careful preparation and, considering the nature of the country to be traversed, very capable leadership, if a desired end is to be attained. Just to mention some of the difficulties, there are no modern means of transportation and all supplies must be transported by carriers. The country is almost entirely unpacified and it would be necessary to provide a guard of armed constabulary which we hope may be furnished by the government of the Commonwealth of Australia, to whom this country has been mandated. The arguments supporting this proposed expedition appear to be sound and no unsurmountable difficulty has presented itself so I am assured that the expedition will be under way shortly after the beginning of the next calendar year.

Dr. Jeswiet: In publications of Sagot et Raoul are mentioned various types of *Saccharum spontaneum* forms that are striped and with colored flesh. It is my belief that these are the progenitors of the striped canes now grown by the native in the mountainous part of these islands. Sagot does not recognize *Saccharum officinarum* but includes it under the botanical species, *Saccharum spontaneum*. I should like to call your attention to these publications as here you may find some suggestions which might possibly be of assistance in this exploration. I believe that the first selections were made by wild men from the canes which nature provided but since

that time it seems that they must have undergone many crosses. I believe that our commercial canes are of the weaker rather than the stronger forms from these islands. If we look at the Philippine Islands, we observe that they have their own canes which I believe were brought back from such islands as New Guinea or the other islands of Melanesia. The importance of sugar cane in this region is very interesting and significant. Sugar cane is both meat and drink for the primitive men woh dwell there.

Dr. Brandes: I have followed these comments with a good deal of interest as they appear to reveal that Dr. Jeswiet has given his attention to the problem of the origin of cultivated canes. My own interest is more narrow, being confined to the possible production of disease resisting kinds but it is evident that we must be at least partly on common ground.

Mr. Moir: We have in Hawaii about fifty varieties of New Guinea canes that were evidently brought to the Island by the early Polynesian navigators. They can be identified as New Guinea canes by comparison with more recent introductions. Some of those at a certain age show mosaic and at a later time the mosaic disappears so that it is practically impossible to find symptoms but we got mosaiced plants from the portions of the stalk infected. Dr. Brandes, I believe, knows this collection.

March 19, 1927. 2 P. M. *Mr. J. R. Johnson in the chair.*

Dr. Brandes: In resuming the discussion of mosaic diseases it has perhaps only a scientific interest but I would like to take up for a few minutes a matter in which I have had a personal interest for many years; that is, the etiology of mosaic and certain biological phenomena in connection with infection. I have brought to the meetings a number of interesting slides showing the actual inoculation of sugar cane and other plants including corn, teosinte, sorghum, *Syntherisma sanguinalis* and *Chaetochloa magna* by means of the insect vector, *Aphis maidis*. These slides are from phatomicrographs of serial sections of the leaf and the insect at the moment of feeding. This is a matter upon which I have already published but we have now an abundance of additional evidence confirming the soundness of the conclusions previously advanced, namely, that the excretion that pours from the tip of the setae bundle as it advances through and between the leaf cells is the actual medium by which the virus is introduced into the plant. It is further found that the phloem tissue of the vascular bundles is invariably sought by the insect for food. You will note in all of the slides the dark colored excretion or saliva which stains a deep red with safranin. (Slides indicating the penetration of the setae bundles into the plant tissues are shown). It penetrates to the sieve tubes and companion cells in every case. The insect is secking food and it would appear logical that the phloem, richer in liquid nutrients than the other leaf cells, should be attractive. It is possible also that the mosaic organism, it is such, finds a favorable medium in the elaborated food which is transported from the leaves to the storage tissues by means of the phloem. At any rate the evidence seems to point out that the virus, once it enters the phloem of the vascular bundles, is rapidly translocated to all parts of the plant through the tissue. It may also later permeate other tissues and the pathological changes that have been observed in the parenchymatous cells, rich in chloroplastids, support this hypothesis. It must be borne in mind, however, that such pathological changes need not necessarily depend upon the actual presence of the organism in those cells. In

other words, it might be an indirect effect in which a deranged physiological activity of one group of cells causes pathological changes in another group dependent upon the first. In support of the idea that the phloem is the tissue by which the virus is actively transported, we have the recent observations of Mr. C. W. Bennett of the Michigan State College on a raspberry mosaic. Bennett found that by girdling a raspberry cane, and thus destroying the cambium layer at that point, he could prevent the advance of the disease past the injured portion. To select a typical experiment a colony of viruliferous aphids were placed on the terminal leaf of a raspberry cane after the cane had been girdled several feet from the tip. The leaves gradually developed signs of mosaic beginning with the tip leaf on which the aphids were colonized and involving successively the leaves in the downward direction but the advance was abruptly stopped at the point where girdling had taken place. All leaves below the part that had been girdled remained healthy during the experiment. The same phenomenon was observed when the inoculated part was below the point of the girdle. The leaves from that point out to the tip remained, to all appearance, healthy. Admittedly this is not conclusive but it supports my view that the phloem of the vascular system is the means by which mosaic virus rapidly spreads.

Another interesting phenomenon which you will note in one of the slides, and which was observed by Mrs. R. C. Starret who was associated with me in this work, is the decided stimulation of the nuclei in cells lying along the path of the setae puncture. The cells rapidly migrate until they all lie adjacent to the setae bundle or as close to it as possible. This is an interesting evidence of response to an irritation. It may be merely for regenerative purposes as the delicate cells are doubtless injured by the passage between them of the minute setae bundle lubricated, as above described, by the excretion which exudes from its tip.

Mr. Matz: I should like to mention that we do see destruction of tissues outside of the vascular bundles. I am inclined to believe from my studies that there is a destruction of cells in the stalk and in the chloroplasts of the leaves and that this is a direct effect of the virus. I believe others also have tried to find if there is a material change in the size of the chloroplasts. In my cytological studies I found infected leaves always show a marked reduction in the size of the chloroplasts. The destruction of paranchyma ecells of the cane cannot be attributed to anything other than the direct effect of the mosaic virus.

Dr. Brandes: We have no definite proof that the virus is confined to the phloem and in fact it is logical to suppose that eventually it permeates other tissues but I believe that the phloem is a tissue to which the insect directs the virus. Reduction in the chloroplasts could be accounted for by indirect action of the virus, but my observations and Bennett's, is that the phloem cells of the vascular bundles are particularly sought by the setae of the insect and that probably this tissue is the means of translocation of the virus throughout the plant at a fairly rapid rate. The evidence points out that it is not so translocated by the xylem.

Mr. Matz: There is no other factor to which we coult attribute the dead cells outside of the presence in the cane of mosaic virus. By more careful or more assiduous work we might be able to find an organism in the dead cells tissues in which the effects of the disease are very evidently localized.

Mr. Johnston: Would you not consider it self-evident that the virus on being absorbed is going to pass out to other tissues?

Dr. Storey: Dr. Brandes, do you consider the rate of advance of the virus as found in the curly top of the sugar beet, namely, six inches in one hour, consistent with the rate of transfer of the mosaic virus through the phloem?

Dr. Brandes: There is so much difference of opinion among plant physiologists concerning the rate of translocation of soluble substances in the phloem tissues that it cannot be said with certainty whether our theory is consistent with them.

Mr. Matz: After many examinations of the different elements in the fibrovascular bundles of mosaic cane, including the phloem cells, no apparent abnormality was found in any of them, yet we do find irregularities in the cells outside of these fibrovascular bundles.

Mr. Johnston: I do not see that we need to conclude that the virus must necessarily invade all affected cells since, if the *toxin* is readily absorbed, it may pass through to the other cells. Since the time is growing short, let us proceed to a discussion of leaf spots and I will call on Dr. Faris who has prepared a report on this subject for Cuba.

SOME SUGAR CANE LEAF SPOTS IN CUBA

By James A. Faris

(Eye Spot Disease, Brown Stripe, Ring Spot, Leaf Blotch, Spindle Blotch and Cold Chlorosis).

This paper presented by Dr. Faris, suggesting Brown Stripe and Spindle Blotch as two sugar Cane diseases new to science, was publisheh in Facts About Sugar for December 3 1927.

DISCUSSION OF SUGAR CANE LEAF SPOTS

Mr. Rosenfeld: I noted cold chlorosis in cane in Peru where it is called "frio" locally. Furthermore, I wish to say that D 433 cane has been observed to be particularly susceptible to *Helminthosporium* spot in Porto Rico.

Dr. Brandes: The chlorosis caused by low temperature is well known in Louisiana where the Type mentioned by Dr. Faris is known as banded chlorosis. I have observed exactly the same thing in greenhouses in Washington during the summer time when the temperature is very high and have attributed it to the effect of water accumulating in the lower part of the leaf whorl following syringing. The heat sometimes becomes injurious to the juvenile tissues of the spindle and when the spindle finally unrolls, every leaf will be marked by a banded chlorotic area.

Dr. Jeswiet: This condition has been noted in Java also and I think it may be caused by high temperature and by drought as well. The tendency is to retard growth and that retarded part, when it emerges, is white.

Dr. Faris: Probably either extreme of temperature will cause suppression of chlorophyl development.

Mr. Crawley: It may be interesting to call attention to the fact that I have observed whole fields of Kavangire cane with these white bands at Central Maria Luisa.

Mr. Rosenfeld: There is another chlorotic condition in this same Kavangire in Porto Rico characterized by longitudinal striping of the leaves.

Mr. Matz: I have also noted the chlorosis mentioned by Mr. Rosenfeld. The width of the stripes varies from fine pencil lines to stripes one half inch wide and even entire leaves may be involved.

Dr. Jeswiet: A similar condition exists in Java where it is recognized as a varietial characteristic, as in the Batjan and Ardjoeno varieties whereever they are grown under favorable conditions.

Dr. Rands: The banded chlorosis has been noted many times in Louisiana. Following a heavy rain, a cold northwest wind resulted in this condition over a large area. The water accumulated in the base of the leaf whorl may have retained the cold for a longer period than the rest of the plant.

Dr. Jeswiet: In my experience, I have frequently noted seedlings produced by certain striped varieties with striped leaves, particularly Batjan seedlings that are entirely without chlorophyl. The striping also occurs in segments of the tassel. Moreover, I found many white seedlings in the Red Fiji cane which is not striped the development of the chloroplastids and is not due to environmental conditions or disease. The seedlings, of course, live for only a short time.

Dr. Brandes: Another interesting condition in sugar cane has been noted in many countries and described under the names Pokah Bong, wrinkled top, etc. A description of the symptoms is to be found in Walker and Wendt's handbook of cane diseases. This condition is brought about by various causes. In some plants, following leaf scald condition, there is a definite response in the form of this peculiar abnormality in the growing point of the stalk. Many times this condition is not to be associated with any definite infectious disease. It has been noticed in Georgia and Louisiana, where a large proportion of the tops of plants in the field develop the condition, especially during periods or warm rainy weather and particularly on good rich lands. It would appear that a too rapid growth following suppression of growth due to drought or other causes may result in this wrinkled top. This form of Pokah Bong does not have especially serious consequences; the plants recover and at harvest time all we find is a series of short internodes produced at the time the leaf symptoms were most pronounced.

Mr. Agee: What varieties are affected in the Gulf States ?

Dr. Brandes: I have noticed this particularly on Louisiana Purple.

Mr. Agee: How long has it been since this was recorded in Louisiana?

Dr. Brandes: I saw it in 1919 but do not that it is recorded in the literature.

Mr. Rosenfeld: I would like to see it recorded now as it has been suggested that Pokah Bong wac brought in with the P. O. J. canes.

Dr. Brandes: I will furnish you with excellent pictures of Pokah-Bong tops and stems taken in Grady County, Georgia, not later than 1920, which was several years before the POJ canes were grown in that vicinity.

Mr. Agee: Is it considered non-infectious in Java?

Dr. Jeswiet: In Java there are several kinds. In fields watered by irrigation during the dry season when water is not abundant, the plants suffer for want of water. The rains come and the leaves develop rapidly and we see Pokah Bong. I think it is only a mechanical thing. The young leaves develop in the narrow space in the leaf sheaths, not well developed by drought, and then when rain comes the young leaves are swollen and cannot come out soon and are crinkled.

Mr. Agee: We have in Hawaii a similar abnormality called Tangle Top, where the leaves are bound for a while and then forced out in a tangle. The young leaves become bound together in some way. We regard it as purely mechanical.

Mr. Matz: I might mention a seedling trouble in which the leaves which are rolled tight in the spindle become hard and begin to dry up at the edges. Later irrigation forces these leaves out of the spindle, at which time they have a crinkley appearance. This is found in an SC 12 (4) seedling which requires a great deal of water.

GUMMING DISEASE

Mr. Matz: This disease was first found at Trujillo Alto, Porto Rico, in caña blanca. A serious feature of the disease is that it has jumped for miles in spreading and is present in the caña blanca variety in many parts of Porto Rico. An experiment with 42 varieties indicated its partiality to certain kinds of cane. The disease is not going to be of great economic importance in Porto Rico as the planters now know how to handle the situation by the use of resistant varieties. Cristalina is susceptible and H 109 is very susceptible. It is surprising that gumming disease is not reported in Cuba. I would like to caution the planters here not to rely on a variety like cristalina which is susceptible to this disease, since if it should gain a foothold the consequences might be serious if no resistant variety is present to replace Cristalina in such an emergency. The B. A. 6032 and the B. A. 11569 are also susceptible. B. H. 10-12 has great resistance and perhaps is immune.

Mr. Rosenfeld: I should like to add to that warning as I intercepted a shipment of 100 stalks of cane infected with gumming disease in Porto Rico designed for Cuba.

Mr. Matz: The D 117 variety is also very resistant.

Mr. Clarke: There is now no evidence of gumming disease in Fiji. In New South Wales a serious outbreak was experienced many years ago in Badila cane which normally is resistant. It spread following the course of badly drained land in wet years. The importance of resistant varieties was recognized following an outbreak in 1892 and a change of varieties was made on this account. Gumming disease is present in Queensland also but I am not so well acquainted with conditions there.

Dr. Rand: In this connection I should like to point out the danger of transporting resistant varieties to new areas. The symptoms are suppressed in these resistant varieties and extra precautions should be taken to prevent them acting as "carriers". This is true of many diseases and is particularly important at the present time, owing to the demand for disease resisting varieties of cane.

Mr. Matz: The organism of gumming disease is probably carried in highly resistant varieties of cane or other grasses not showing symptoms and when a susceptible sort is introduced it becomes infected and shows the symptoms. I have not been able to isolate the organism from soils.

Mr. Clarke: Mr. North, Pathologist for the Colonial Sugar Refining Co. tried to bring about root infection by planting healthy cane sets in holes from which stools affected with gumming had just been dug out. No infection during the following 8-9 months was obtained. The Mahona variety which was considered a desirable kind, was sent out to one of the Fiji mills in 1918. At the end of 1921 leafscald disease was first discovered in it at the Station. A second mill area supplied from the station with Mahona material was at once inspected. The disease was not found at this mill, however, until 12 months later.

CANE STEM GALLS

Dr. Faris briefly reviewed papers by Lyon, Kamerling and Barnum on this subject. These papers were published in the Hawaiian Planters' Record for October, 1926, the paper by Kamerling being a reprint from the Archief Vol. 1, 1900. He stated that accesory buds had been found on some of the P. O. J. canes in the variety collections of the Tropical Plant Research Foundation Sugar Cane Experiment Station at Baragua, Cuba, especially in P. O. J. 826 and P. O. J. 979. Attempts to germinate these resulted in a bunch of grass-like plants which never amounted to anything and were discarded.

Mr. Agee: Dr. Faris, do you consider these galls infectious?

Dr. Faris: I cannot say as we have not carried out any experiments to determine that point.

Dr. Brandes: It is interesting to note the remarkable similarity in external appearance of these galls, associated as they are with numerous adventitious buds, and that of the well known crown gall caused by *Bacterium tumefaciens.*

Dr. Jeswiet: In Java it is thought that these galls are not infectious because planting such material, if it produces plants at all, gives rise to new plants that are without galls, also the second generation by cuttings.

ROOT GALLS

Dr. Faris: I would like to mention a form of root gall found by Mr. Stahl in his experimental cages December 22, 1926, upon the roots of sugar cane. These galls are formed more or less numerously along the vigorously growing roots. They range up to the size of a pea and are nodular on the surface, apparently growing by dichotomous branching. They have an olive green to brown center when old and appear to be of bacterial origin, as I made numerous free hand sections, all of which showed this olive green center to be filled with bacteria. These galls began to disintegrate after a couple of months and are becoming difficult to find on the plants at the present time. They closely resemble the galls upon the roots of certain legume plants. The roots of the cane appear healthy. If these galls are of the nature of the root nodules on leguminous plants, it is of very great importance to learn the requirements for their growth. They were found on both P. O. J. 2725 and Cristalina cane during January and February 1927. These canes were growing in pots in a compost of stable manure and red clay. The nodular galls were formed freely on the roots in the port and upon those which had grown through the drainage openings at the bottom of the pot. The memembers will have the opportunity of seeing these peculiar galls when they visit the Experiment Station at Baragua.

Mr. Matz: I wish to mention the occurrence of mature nematode root galls which I have found at one of the places visited in Cuba upon my recent trip through the Island. I think it will become more and more important. In Porto Rico it is found only on loose soil. It is remedied there by incorporating organic matter in the soil.

DRY TOP ROT

Mr. Matz: Porto Rico is unique in being the only important cane region where this disease has been reported. I found it, however, in Barbados last year. I consider top rot to be the most serious disease in Porto Rico. It is found in the Añasco Valley, on the east coast at Fajardo and on the north coast at various points. The symptoms

are a drying out of the leaves in stripes extending from the tips downward and not from the edges inward. The upper joints of the cane are shortened and the stem looks like a tower of stories of decreasing diameter. The disease occurs in wet land. A few cases have been found, however, in other situations. Good drainage is indicated but has not always remedied the trouble. B. H. 10 (12) resists the top rot to a great degree and S. C. 12 (4) also. The former is planted on the low heavy soils and S. C. 12 (14) on the lighter, better drained soils. The organism, *Plasmodiophora vascularum,* is almost anaerobic, loving the wet unaerated soils. Cristalina cane is susceptible. The organism must get into the xylem and probably is not a strict parasite. It may follow injury by animals or other fungi. It is not found in Uba cane or 36 P. O. J. It may be that this is the explanation for ability of these varieties to ratoon in Porto Rico.

Dr. Jeswiet: Referring again to the matter of adventitious buds, we have a great deal of the bunchy top condition in Loethers cane. In planting tops from this we found that many of the nodes were without buds. In examining these bunchy tops we have frequently found vestigal panicles among the foliar parts.

Mr. Agee: Dr. Lyon was originally of the opinion that bunchy top was due to deformed tassels. He is now inclined to believe however, that it is another thing.

Dr. Brandes: The recent work of Dr. Sartoris on seed cane deterioration in Louisiana is worth mentioning at this point. It is a problem of greater importance in connection with cane culture in the subtropical and temperate areas rather than in the tropics. One of the organisms causing a rot of seed cane which was described by Dr. E. J. Butler as *Sphaeronema Adiposum,* has been determined by Dr. Sartoris in the course of a detailed cytological study to be in reality an ascomycete which he has referred to as the gama Ceratostomella. Because of the small size of the asci and the early desintegration of the ascus wall, the true identity of this organism evidently escaped the attention of Dr. Butler. This trouble has been serious only in a few small areas in Louisiana. The common name of this disease is black rot of seed cane. A paper on the subject will appear shortly in the Journal of Agricultural Research.

DOWNY MILDEW IN FORMOSA

By Dr. T. Miyake

Formosa may be roughly divided into three sections:

I. The North, which is rather cold and has its principal rains in the winter;

II. The Middle, and

III. The South, which is warm, has periods of complete drought, and has its principal rains in the summer.

There are two Downy Mildews: (1) Sclerospora spontanea, which is indigenous to Formosa and which affects Sacchrum Spontaneum, Miscanthus sinense, and Miscanthus japonix. This is found in all parts of Formosa, in Southern Japan, Southern China, Cochin China, and the Philippines. S. Spontanea also occurs sometimes on Saccharum officinarum and on Zea mais.

(2) Sclerosposa sacchari, which has only been found in Southern Formosa and never in the Middle or North. This affects S. offcinarum, doing its greatest damage on the low-fibred sweet kinds such as Badila, POJ 161, and Rose Bamboo; and much less damage to high-fibred kinds such as China and Yellow Caledonia.

Sclerospora sacchari was introduced to Formosa in 1917 with some cane varieties imported from Brisbane, Queensland to Shinko, the Government Experiment Station

six miles north-east of Tainan. Thence it was distributed in cuttings to all Southern Formosa.

Dr. Miyake studied the disease in 1909 and published a report on it in Japanese in 1910.

The disease did its worst damage in 1913, 1914 and 1915.

The affected area is getting smaller every year. The amount of the damage in badly affected fields is about 20% – 30% reduction in sucrose content. The method of control is to destroy the cane on the diseased field and those immediately surrounding it by burning the standing cane and then ploughing it out, and completely destroying it.

The fields are then planted with sweet potatoes, peanuts, or legumes for one growing season; after that they are planted with cane derived from clean seed.

PROCEEDINGS OF HAVANA CONFERENCE

Section IV.

SUGAR CANE VARIETIES

Jacob Jeswiet, *Chairman.* H. F. Clarke, *Secretary.*

The History of Sugar Cane Selection Work in Java. *By Jacob Jeswiet.*
The Harvard Seedlings of Cuba. *By D. L. Van Dine.*
Sugar Cane Hybridization Sheds. *By T. S. Venkatramen and R. Thomas.*
The Varietal Revolution in Porto Rico. *By C. E. Chardon.*
Propagation of Cane by the "Sprout" Method. *By Jacob Jeswiet.*
A List of the Cane Varieties of Cuba. *By F. S. Earle.*
The Flowering of Sugar Cane. *By Jacob Jeswiet.*
World Material of the Genus Saccharum. *By Jacob Jeswiet.*
The Sulphurous Acid Method in Cane Breeding. *By H. P. Agee.*

SECTION IV

SUGAR CANE VARIETIES

General Session, March 17, A. M.

THE HISTORY OF SUGAR CANE SELECTION WORK IN JAVA

By Dr. J. Jeswiet.

There are two ways in which it is possible to secure a better variety of sugar cane by selection: 1—Selection from the world material which was available before seedlings were secured by European works, and; 2—Selection after crossing the original varieties.

1.—*Selection from the world material.*

The Java sugar cane culture was started with the primitive soft white types, such as white Japars and some others "White" or yellow canes. Probably also with the "teboe Koenning" or "teboe mata", etc., idential with the now well known Lahaina cane. These soft canes which are still used as chewing canes in Java, were chosen because of their adaptability to crushing in the wooden mills worked by oxen. The sugar product was then from 25 to 40 piculs per bouw. It was about 1850 that Gon-

zalvez tried the black Cheribon cane, from which the sugar per bouw rose to about 60 piculs. The culture was done by Goverment order, the natives doing the work, and the sugar was manufactured in factories by European and other contractors and had to be sold to the Government. In 1879 sugar cane culture became a free culture and under these conditions the sugar production went up to 80 piculs per bouw. At this stage of cane cultivation in Java the industry was struck by two calamities. In the first place the progress of beet sugar production, by which the prices went down, and in the second place the sereh disease which destroyed the crops in many places. Science was called upon to help the industry and in 1885 Soltwedel became the first Director of the first experiment Station at Semarang, Java. In order to control the sereh disease and secure sound cane for planting the factory fields, Soltwedel advised that seed nurseries be planted in the mountains at an altitude of 1500 to 3000 feet. In this way the standard cane of Java was retained in cultivation. Not content with this solution, however, many importations were made in the hope that immune canes would be found and from this time dates the varieties Loethers, Fidji, Batjan, white and black Manila, Borneo cane, etc. None of these varieties were immune to sereh and Black Cheribon continued in cultivation bringing the sugar production up to 100 piculs per bouw. In 1890 the Government made another attempt to find immune varieties by sending Kobus to British Indis. He brought back to Java, through the quarantine Station at Banks some canes among which was the Chunnee variety. This proved to be immune but was not of sufficient weight. The importation was important, however, as an immune variety was crossed with other canes and from this the POJ varieties of Chunnee blood were obtained.

After this the Java Sugar Industry left this method of selecting from the original canes and went to the second possibility, that of selecting from crossings between the original varieties.

II.—Cane obtained by selection after crossing.

This subject may also be divided into two parts:

(1) Crossings between varieties in the species *Saccharum officinarum* and (2) crossings between different species of *Saccharum* with *Saccharum officinarum,* to to secure immunity against diseases.

(1) In 1862 Noto Hami Prodjo, a Javanese, sent little plant sobtained from sugar cane seed and published a report about this in the journal of Science for Netherland India (volume 25, page. 359) in 1885 Soltwedel sought cane seed from the wild *Saccharum spontaneum* and got young plants from the seeds. In 1886 he went on with the work of varieties, Mauritius cane, of the species *Saccharum officinarum* L., and with the Loethers canes, and cut seeds from the well-known Glonggong (belonging to the genus *Erianthus,* closely related to *Saccharum*. In 1887 he tried many crossings between the Loetheds varieties and the *Saccharum spontaneum* by castrating the flowers of both. He did not succeed in this attempt but was the first to try the experiment of artificial crossing. In the same year Doctor Ostermann in Java produced seedlings from a Java variety probably the Ardjoena cane. In the same year Soltwedel produced seedlings from *Saccharum officinarum* and a strong cane from Hawaii, just which cane is not known. Independent of the work of Soltwedel, Harrison and Bovell produced seedlings in Barbados in 1889, and in 1890 there were cultivated on that Island 2,300 seedlings. Soltwedels' work stimulated great interest and was continued by Moquette, who raised many seedlings from the Fiji cane. In the year 1892 he produced about 5,000 plants from 38 different varieties. Doctor Walker also worked with him on this subject at the Pasoeroean Station and gave us

many interesting data regarding cane, flowering and crossing. He discovered the cause of the sertility of the Black Cheribon cane and obtained the well known seedling 100 POJ in 1893. This cane is perhaps a crossing of the Banjermasin with Liethers. Bouricius crossed the Black Cheribon with the Fidji cane and made still other crossings, producing the successful seedling 247 B. These two varieties brought up the Java sugar yield to an average of 120 piculs per bouw. In 1903 Stok crossed the Black Cheribon cane as a mother with the Batjan cane and obtained DI 52.

In 1911 John W. Vensteegh selected E K 28 and this with DI 52 brought up the sugar production of Java to about 150 piculs of sugar per bouw in the year 1925. Besides this many other seedlings were produced which were more or less utilized in field planting, but notwithstanding these crossings which advanced cane culture in Java, all of the canes were susceptible to Sereh and mosaic disease. Therefore, it was necessary to make a still more rigorous selection to control these two diseases which forced us to maintain cane nurseries in the mountains. These were all crossings between varieties belonging to the species *Sacharum officinarum.*

(2) Moquette, a planter in East Java, and Wakker, the second Director of the Experiment Station at Pasoeroean were the first to make crossings with a cane called Kassoer cane found in a wild state in the volcano Moeriah by M. Krüger. That cane grows very vigorously, has long ,upright stalks, strong roots and dark green leaves. It was not attacked by the mosaic disease nor the sereh. The crossings made by Moquette were not published; those by Walker were described by him in the Archief voor de Java—Sucker—Industrie. He states that the leaves of these first crossings with sugar cane are dark green and believes they may be immune, but as canes they were disappointing; leaning badly, hollow inside, low sugar content, etc., a lot of undesired characters. Therefore he warns his collegues not to cross any more with the Kassoer cane. That this was a crossing with a species other than *S. officinarum* L., will be made clear below.

As I published formerly, the cane Chunnee, imported by Kobus in 1890, belongs to a distinc species, *Saccharum Barberi* Jesw. This was already predicted by Kobus himself. The crossings made by him brought in the seedlings from *Saccharum officianarum,* vigorous growth, strong roots, but unfortunately almost total liability to mosaic disease and insufficient weight. The result are the canes now known in the world as being adapted to extensive culture with rather good results P O J 36-139-213-228-234, etc. much cultivated in Argentina, Formosa and now in Cuba. In order to keep them free of the sereh disease, the Java factories planted them on their heaviest soils or salt soils, or soils which were every year inundated. In the better soils the varieties of *Saccharum officinarum* gave far better results. Later on Kobus made crossings between the Chunnee seedlings themselves and got some better canes such as 1499-1547 and others. Those he made on a rather high scale. Later on he crossed his seedlings of first Cunnee crossing once more with *Saccharum officinarum* and got better types, for instance the crossing 147 POJ with Black Batjan; only two seedlings of this crossing were kept–the numbers 1090 and 1091, the latter being a rather thick, erect, good cane. So by once more crossing with the species *Saccharum officinarum* Kobus got in the cases left to us a higher cane weight and nicer cane, but as in all Chunnee crossings, the types were susceptible to Mosaic Disease.

I told you already that Soltwedel (1887) tried to cross *Saccharum officinarum* with *Saccharum spontaneum.* Later on Walker and Moquette crossed with the wild Kassoer cane. By these crossings they meant to get rid of sereh and mosaic diseases.

From these canes not one was left to us; they were thrown away. Later in 1910 Wilbrink made once more the crossings with the Kassoer cane and took as female canes the Striped Preanger cane, Black Cheribon and 100 POJ. The whole set was in the fields of the Station when I took charge in 1912, and had not as yet been selected.

I made crossings and sowed out seeds from wind pollination of sugar cane tassels and also tried to get good types by self-pollination. I expected that the factor thickness from *Saccharum officinarum* as a Mendelian character would come out in these seedlings of the Chunnee blood, but all the Chunnee sedlings gave most times smaller or more slender canes than the mother canes. In *Saccharum officinarum* it was the same case. I got only some nice types in the New Guinea canes but they did not flower in those years. Constancy of characters was not reached. I tried this way of working according to the work in maize, but the results were too bad in the trials in F 1 and F 2 generation, so I gave up this work. Yet it had its worth. Later when for instance I crossed the same form of *Saccharum officinarum* with the Kassoer cane itself and with one of its selected seedlings obtained from self-pollination, the contrast between the seedling plots was considerable. In the Kassoer crossing there were a lot of bending canes of bad habit, many with roots on the stalks and other bad characters and only some of good shape. Those from the crossing with self-pollinated seedlings of Kassoer cane were of a very nice habit of growth, erect, equally long, many of them of good shape.

In the year 1915 we had a very dry year in Java and then we lost a good many of our seedlings by drought. Exceptions were the Clunnee and the Kassoer crossings. The last group showed even in this year great resistance and looked the best.

Then in regard to the Chunnee crossings made by Kobus obtained by crossing twice back on *Saccharum officinarum*. Therefore, I carefully selected the plots of the Kassoer crossings left by Wilbrink. I began in 1926 to cross the 100 X Kassoer crossings and the Cheribon Kassoer crossings with some types of *Saccharum officinarum*. I expected to get the same results as in the Clunnee blood in regard to thickness and to get rid of the mosaic disease.

Then I tried also to combine the seedlings of Chunnee and Kassoer blood to have from both parents the strong roots, the immunity against sereh and from one of the parents the immunity against mosaic disease.

These crossings gave rather good results in that year. It was the first attempt and although they were not very acceptable types of cane in comparison with the cultivated types of *Saccharum offcinarum,* they looked much better than the Chunnee crossings, above all by the dark green leaves and the longer, straighter habit. Notwithstanding the fact that the weather at crossing time was rather bad and that we could not combine the best male canes with these Kassoer crossings, there was a very distinct promise that this way of doing might be a good one.

In 1917 we had very nice rainy weather during crossing time and many canes tasselled and did this in very different groups all in the same time. I could do the work now on a very large scale and crossed each of the best mother canes of the 100 X Kassoer and the Cheribon X Kassoer groups with the same series of good male types of *Saccharum officinarum*. We got many different combinations and many seedlings. By this method we could know which of the Kassoer mother canes gave the best results in its offspring. The best one of this year was 2364 POJ (100 X Kassoer). It gave in most of the crossings with different males quite acceptable canes.

At the same time I made a lot of crossings in the Chunnee blood in the same way. By planting the seedlings of Kassoer blood in the southern part of our field and those of Chunnee blood in the northern part, it turned out that in the latter part of the field the plants looked yellowish in their leaves and had not such a good habit as most of the dark green, tall Kassoer plots.

In 1915 I supposed the Kassoer cane to be a *Spontaneum* crossing of the wild cane (*Saccharum spontaneum* L) and one of the varieties of the real sugar cane (S. *officinarum* L.) I got this idea by examining the hair pattern and the bud and sheaths. I have proven this supposition by making crossing of S. *officinarum* and S. *spontaneum* in 1917, from which I got seedlings similar in habit to Kassoer with the same vigorous growth and dark leaves. In 1921 Bremer proved cytologically that this cane is a result of species crossing by examining the number of chromosomes and finding it to be the same as the original Kassoer.

Therefore, all of our Kassoer crossings were species crossings. We had in Kassoer a cane directly derived by a first crossing from the wild cane and so probably possessing the immunity characters against disease and resistance against bad circumstances. Now we could produce more Kassoer types from other parents for use in crossings for more possibilities. The discovery of this relation of Kassoer gave us more encouragement to continue this method of obtaining new immune varieties.

By ennobling Kassoer cane twice we got selected types of tall, upright, strong, thick habit canes, commercially immune against sereh, some of them in a small degree susceptible to mosaic and most of them with strong roots. They proved to be quick growers, very easy to propagate on heavy, less favorable soils. Even in the dry time when the heavy soil showed very deep cracks and all noble types died off by the harm thus done to their root system, these Kassoer blood canes remained healthy and green.

In the seedlings of the year 1917 I got out of the crossing 2364 by E K 28 = (100 by Kassoer) × E K 28, the canes 2714 POJ, 2722 POJ, 2725 POJ. All three are good thick, erect canes, with rather strong roots, commercially immune against sereh and mosaic, but all three tasseling rather abundantly. Moreover, 2714 may have root troubles when grown on badly drained soils; 2722 under certain circumstances grows too slowly, needs much water and when young prefers a higher application of fertilizer to make a quick start; 2725 tassels too early, after which it stops growing and has, therefore, to be planted very early. The two latter have a good sugar content, but the other characters make then less acceptable in the field. In the same crossing mentionned I found in 1917 in the same plot next to the tall, thick, freely tasseling canes, also others of less girth, but long-noded and not flowering, however, too slender to be good field canes. Every year I attempted to get a large number of this desired crossing, but until 1921 the atmospheric conditions at crossing time were too dry. In 1921 we had good weather and obtained a great number of seedlings of that crossing and then I was able to select for one bearing all good characters desired for a commercial cane in Java. This cane occurred in the 2500 seedlings and is 2878 POJ, the parentage of which is shown in figure 18.

As these strongly growing types kept on flourishing on the good soils and thereby remained low in sugar yields, during the dry milling season, I tried to cross them once more with S. *officinarum*. The types are nice but they did not have the vigor of growth of the previous set, not even on the good soils.

In the Chunnee blood I got in this way (crossing back the Chunnee type three times on the S. *officinarum*) some rather good types in habit and sugar content but they are severely attacked by mosaic and sereh.

The Kassoer seedlings of that degree are better but the immunity limit to mosaic disease seems rather to be reached in seedlings of crossing back twice such as 2364 by E K 28.

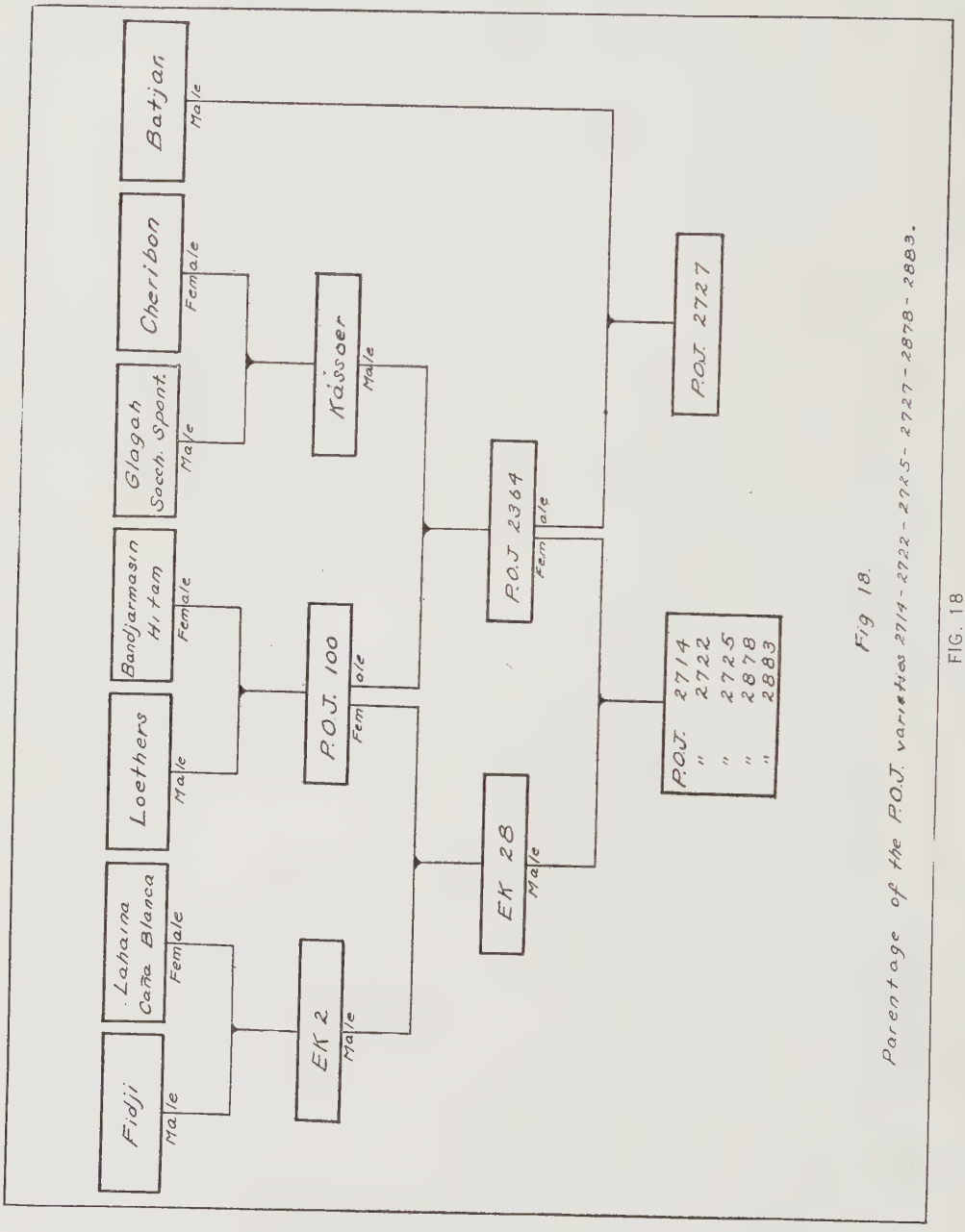


FIG. 18

Discussion

Mr. Earle: We are all certainly very much obliged for so clear an account of the actual methods in Java of seedling production and crossings. I would like to ask to what extent Chinese blood has figured in Java, that is the Uba type of cane. Prof. Jeswiet answered that they had worked with this cane for the last four years

and had found that the seedlings were too slender and not so long as the crossings with the *Saccharum spontaneum*. The wild type of Java is better than Uba types for immune seedlings.

Another question is whether your selection is mainly based on growth and habit characters or on chemical analyses.

Prof. Jeswiet stated that selection in the field was based on growth and habit and that this was a great exclusive selection, but that in the factory Brix and polarization as factors for sugar content are used, and that this investigation is repeated over three years.

Prof. Earle asked if there were any trials concerning time of maturity.

Prof. Jeswiet answered that in the second year there are two analyses of full grown cane in samples of five stalks in the months of May and June. In the third year larger plots are available, and there are four or five fortnightly analyses. This may give a slight idea about the time of ripening and how long the ripened cane remains on the same level of sugar content. How the cane really behaves, will turn out from the field trials in the factories.

Mr. Agee asked about the severity of elimination.

Dr. Jeswiet answered that they regard only the best ones, for a very severe selection in the field is the first base, followed by a second pitiless selection in the factory on solidity and sugar content. Yow know by this way that you keep only the best plants and with a small number of best ones you may more easily reach your aim by the survival of the fittest.

Dr. Menendez said he was very much interested to know something about 2714, 2725, 2727, and 2878.

Dr. Jeswiet: 2725 POJ is as high in sucrose as E K 28. 2714 POJ is lower in sucrose, but is suitable for heavy soils. Dr. Menendez said that 2725 has been planted with poor results in Porto Rico because it was early in arrowing. Dr. Jeswiet answered that 2725 POJ is only used in Java circumstances for very early planting so as to allow it to grow up before the other one. 2714 POJ arrows abundantly and too quickly. POJ 2727 is a nice cane sparcely arrowing and good for heavy soils.

Mr. Rosenfeld stated that POJ 2725 may be planted in April instead of other varieties planted in August. It may be harvested in May of next year. It has very hairy leaf sheaths, bad for hands and eyes. D 433 is also bad for the same reason. Dr. Rands asks on what soils seedlings are first to be grown, on one or on several.

Dr. Jeswiet answered that the seedlings were always planted on very heavy cracking black clay in an arid climate, and they are there grown until they are selected for about ten months. There is always irrigation. They know nothing about cane selection without irrigation.

Dr. Faris said he was interested in the ratooning value of the canes.

Dr. Jeswiet answered that there is no real experience in Java, because they have no ratoon cane. We may judge only by a method of better propagation and also by the amount of seed produced in the time of six months. Afterwards the cane is cut and then we have ratoons from six months old canes. These ratoons produce very well on heavy soils.

Dr. Lopez: Does the sugar content vary from the first selection to the later ones?

Dr. Jeswiet: As a rule the sugar content is of the same rate the following years. The figures about it are always to be studied in relation to the meteorological factors of the year. If they are considerably lower, the cane is rejected.

Mr. Rosenfeld: In Argentine 2714 POJ is not as good ratooner as 36 POJ and 213 POJ.

Plant cane of 2714 POJ produces very long stalks; the ratooning canes may be much lighter than 36 POJ and 213 POJ.

THE HARVARD SEEDLINGS

By D. L. Van Dine

Through the combined generosity of Mr. Robt. M. Grey, of the administrative officials of Central Soledad, and of Harvard University, the seedlings produced by Mr. Grey at Harvard Garden, Soledad, Cienfuegos, have been added to the collection of varieties of the Cuba Sugar Club Experiment Station of the Tropical Plant Research Foundation. For the past quarter of a century Mr. Grey has been interested in the creation of new economic plant varieties. This work has included the breeding of sugar cane and has resulted in the production of many new varieties. The dominant idea in Mr. Grey's work has been to produce a variety that would successfully replace Cristalina in the older cane areas where the standard cane has shown indications of failing. Those of these new canes that have given promise of replacing Cristalina on the older cane lands, under the dry season conditions of Cuba, have been retained and tested under field conditions and also some of them have been used as parent stock for further productions.

The scene of Mr. Grey's long years of endeavor constitutes now the Harvard Garden Soledad, Cuba, of which he is Superintendent. The Garden, a part of the Institute of Tropical Biology and Medicine of Harvard University, contains a wonderful collection of plants among which can be found representatives from most parts of the tropical world. In the case of fruits, many of them have been bred and greatly improved over the parent stock. The Garden is not only a monument to Mr. Grey's work, but also to the high esteem in which the late Mr. Edwin F. Atkins held the study of and experimentation with plants. His endowment to maintain the Garden and to continue the work so well established there, is a fine contribution to Cuba and to the tropical world in general.

Mr. Grey has designated his seedlings as the "Harvard" varieties, indicating the name under which the Garden is now known. Out of thousands of varieties produced eight which have successfully replaced Cristalina under his conditions where they were tested and these have been donated to the Station for further trial and for such ultimate place as they may find in the sugar industry of Cuba.

The eight Harvard seedlings which have just been added to the collection of the Cuba Sugar Club Experiment Station are as follows:

Harvard 1192.

Produced in 1908. A seedling from Hrv 219. Considered by Mr. Grey to be a general purpose cane.

Harvard 1306.

Produced in 1909. Barbados White Sport X Cristalina. Considered to be a good cane for hill lands. Resistant to dry conditions and to mosaic.

Harvard 9072 (equals Hrv 9092).

Produced in 1917. Hrv 6047 X Cristalina. Considered a good cane for hill lands.

Harvard 12029.

Produced in 1921. Cristalina X Barbados White Sport. Progeny of three generations, beginning in 1918. Observed growing on hill land, February 18, 1927, where Cristalina had failed in the plant crop. The cane was withstanding drought conditions in an excellent manner. Mr. Grey furnished the following interesting analysis of this cane.

Hand-mill Analysis of Hrv 12029.

April 15, 1923. 12 months old, plant cane.

Brix	23.88
Sucrose.	23.02
Purity	96.40

Mr. Grey says that at 12 months he has never seen this cane below 19 sucrose or 90 purity, hand-mill test.

Harvard 13013.

Produced in 1922. Seedling from Hrv 6039. Rather low in sucrose, but considered a good cane for low, wet lands.

Harvard 13063.

Produced in 1922. A seedling from Hrv 1418.

Harvard 14656.

Produced in 1922. A seedling from Hrv 10029 (equals Hrv 10028).

Harvard 15212.

Produced in 1923. A seedling from Hrv 6307. Has done well on hill lands, under dry conditions.

Also of interest is the parent stock from which the above varieties were produced. The following varieties that have served as breeding stock in Mr. Grey's work have been sent by him to the Station collection:

Barbados White Sport.
Cristalina.
D 95.
Rayada (Cinta).
Java 51. Introduced to Cuba in 1901.
Harvard 219. Produced in 1904. A seedling of Rayada (Cinta).
Harvard 6047. Produced in 1914. D 95 X Cristalina.
Harvard 6307. Produced in 1914. Cristalina X Barbados White Sport.
Harvard 10029 (equals 10028). Produced in 1909. A seedling from Java 51.

The following varieties representing parent stock have not as yet been added to the collection of the Station, but their origin is as follows:

Harvard 331. Produced in 1908. A seedling from Hrv 219.

Harvard 1418. Produced in 1909. A seedling from Barbados White Sport.

Harvard 6039. Produced in 1914. A seedling from Hrv 331.

Harvard 15091 has been suggested also by Mr. Grey for trial when cuttings are available. Its history has not as yet been received.

In addition, the following varieties from the collection of Harvard Garden have been sent to the Station by Mr. Grey:

Caña de la Tierra Colorada. Also known as Negrita, Caña Fraile, and Black Mountain.

Daniel Dupont (Hawaii Striped Tip) *

Harvard Sport 1904. (Purple sport from Daniel Dupont or Hawaii Red Trip)

Harvard Sport 1905. (Gren sport from Daniel Dupon or Hawaii Yellow Tip)

Harvard 221. (Saccharum officinarum variety pubescens).

Saccharum biflorum. A desert cane from Algiers.

(*) The Daniel Dupont cane has been determined by W. W. G. Moir of Hawaii as the Hawaii Striped Tip.

SUGAR CANE HYBRIDIZATION SHEDS

Submitted by

Rao Sahib, T. S. Venkatraman and *R. Thomas*

I.—Certain risks associated with hybridization of canes in the field.

During the arrowing season for sugar canes the atmosphere in a cane field is heavily laden, chiefly in the mornings and forenoons, with the pollen of the different varieties in flower at the time. Owing to its adverse effect on seed setting the protection of the treated flowers against unintended pollen, by enclosing such flowers in paper or cloth bags, is unavailable in the sugar cane. The removal of the pollinated arrows away from the field of flowering canes is one method for securing greater certainty in the parentage of artificially raised hybrid seedlings.

At Coimbatore in India the arrowing of sugar canes coincides with the period of the North East monsoon; and during this period rains are not uncommon. Such rains, if at all heavy or continuous, discolour the cane stigmas (probably through the washing out of the stimatic fluid) dislodge the pollen grains and induce fungoid growths on the stigmas, with the result that the seed setting is adversely affected. In the past valuable seed material, some of them obtained after difficult pollination, had been lost through such rainy weather. The loss of such material becomes serious,

when, for any reason, it becomes impossible later to repeat the combination. Here we have a second reason for removing the pollinated arrows away from the field and under suitable cover.

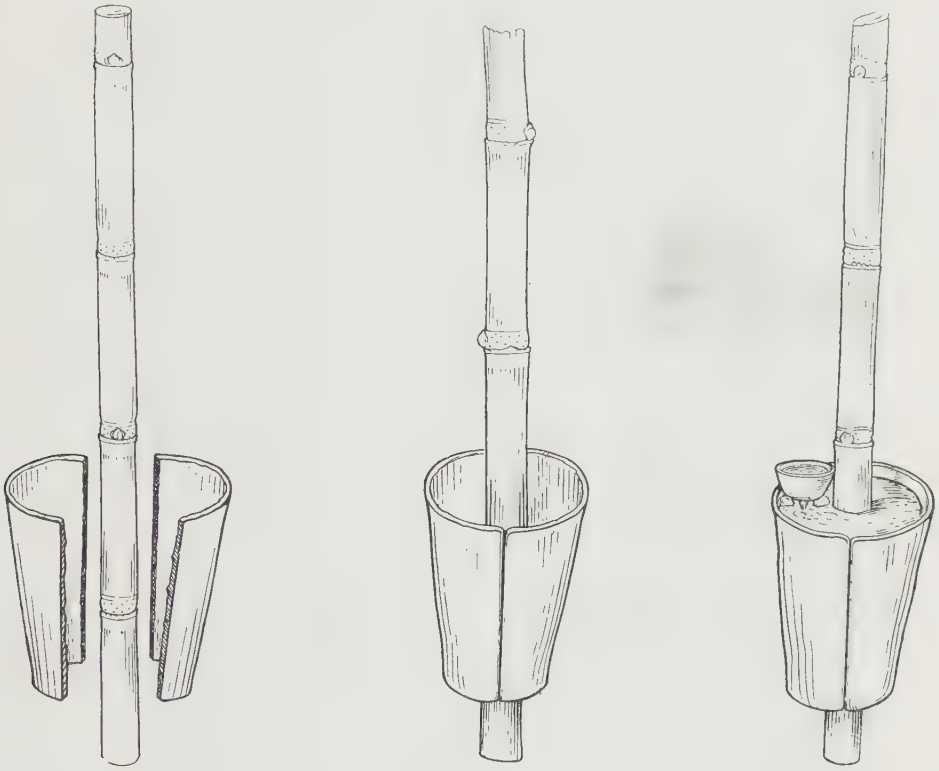


FIG. 19

Cheap earthenware apparatus employed for inducing a fresh set of roots on sugar-canes, it is desired, to isolate from the field.

II. *Isolation of live arrows away from the field of flowering canes.*

By the artificial inducement of a new set of roots on the cane, whose arrow it is desired to isolate from the field, the authors have been able to segregate the arrows without adversely affecting either the pollen or the seed setting of the treated arrows. (*) The pictures in Figs. 19-20 illustrate the esential processes involved in the method. This method has rendered possible a further advance in the breeding technique during the current season, with the definite object of carrying out the cross pollination in a shed, especially erected for the purpose and without the risk of exposing the pollinated arrows to unfavourable weather conditions in the field.

(*) Venkatraman, T. S. and Thomas, R. Sugarcane Breeding Technique. Agricultural Journal of India, Vol. XXI, Part III, May 1926.

FIG. 20

Shows fresh roots resulting from the manipulation indicated in Figure 19.

III. *The sheds described.*

The special hybridization sheds are best erected in a portion of the area away from the field of flowering canes. The authors have found it convenient to place these sheds among a young cane crop, if one is available. The sheds consist of a piece of tarpaulin placed as roofing over bamboo supports and are simple and chea

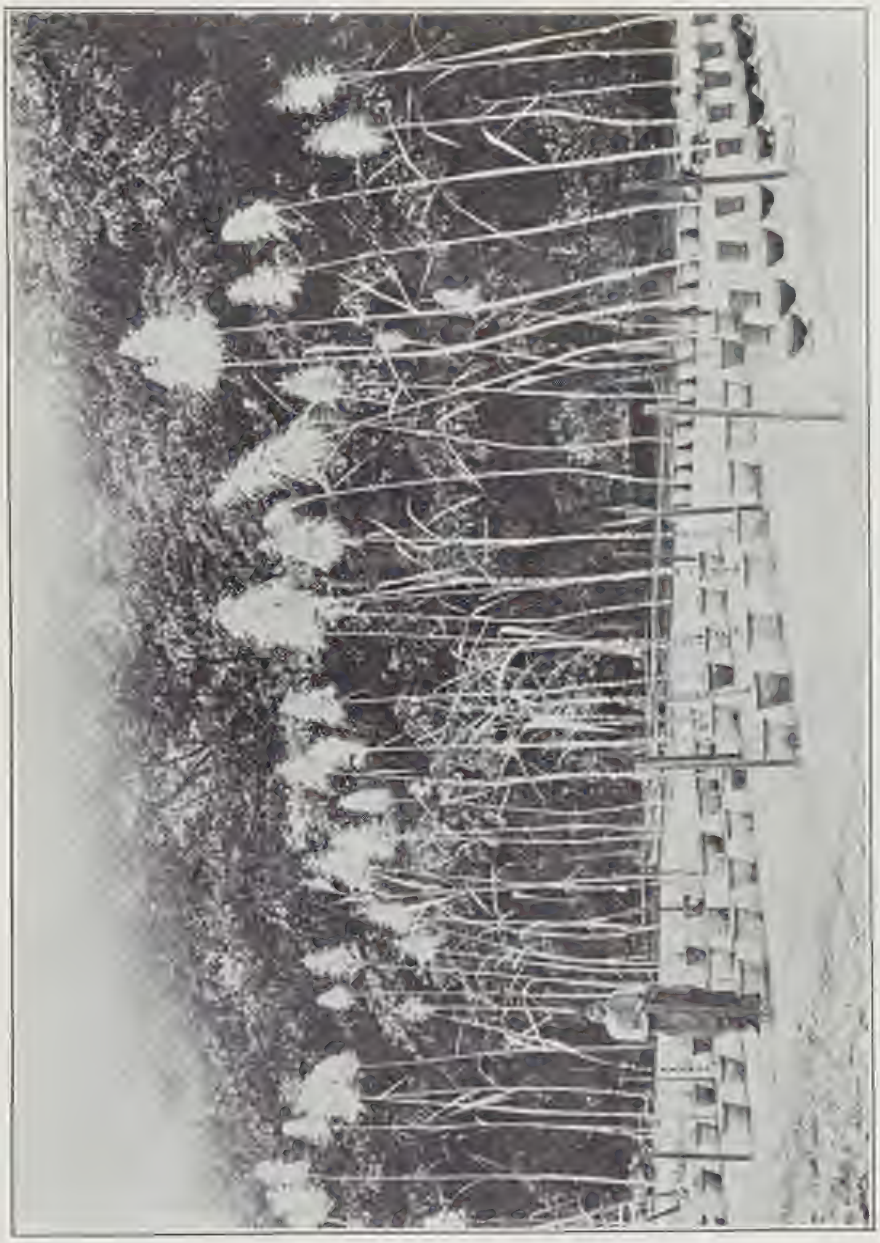


FIG. 21

Sugarcane arrows isolated from the field of flowering canes for hybridization purposes after artificial rooting

p to put up (Figure 22). The tarpaulin sheet carries a bamboo at either end to enable the rolling in or out of the sheet as desired. It is essential that the roofing should be capable of easy and quick manipulation, to afford an immediate cover in the event of a rain and a quick removal soon after it. An unnecessary cover over

the arrows, in close or rainy weather, causes the development of fungoid growths on the stigmas.

It is now presumed that the two parents, which are intended to be crossed with each other, have a fair number of canes, in short blade or about to get into short blade, artificially rooted for subsequent isolation. For brevity, the arrows of the

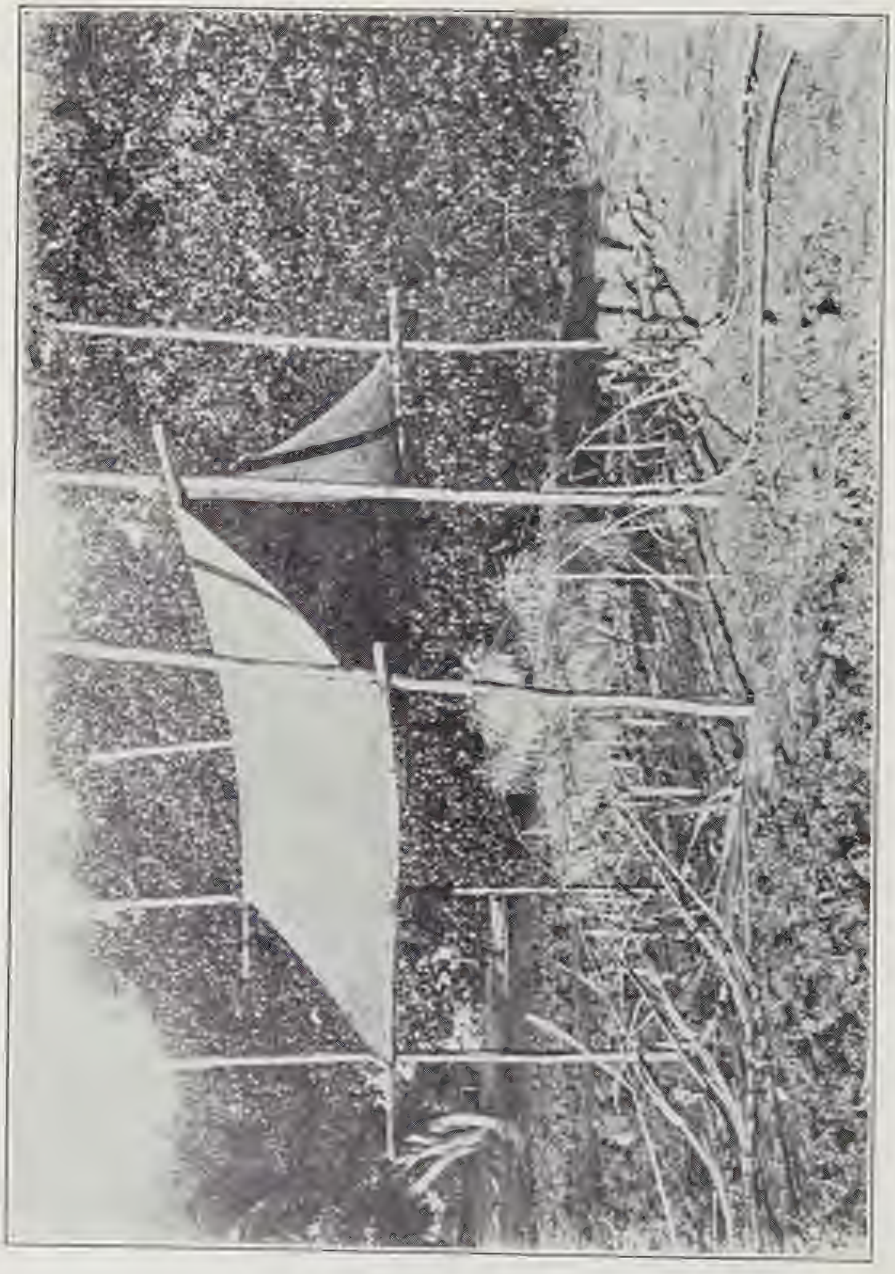


FIG. 22

Temporary field sheds, affording shelter from rains, for cross pollinating sugarcane arrows.

variety to be used as the male parent will be referred to hereafter as the *male arrows* and those of the other *femal arrows*. The arrows of the two parents, just emerging or about to emerge from the sheaths of the flag leaves, are now placed together inside the shed, the male arrows being placed at a convenient height above the female

arrows, to facilitate the latter getting the full benefit of the pollen grains that would drop down from the male arrows at the time of another deheiscence. Generally, only such varieties are used as female parents, as posses little or no healthy pollen of their own; this is done to reduce the chances of selfed seedlings in the resultant batch.

Each shed is intended to keep going at a time only one kind of cross pollination. If more than one combination is desired to be carried on concurrently, a separate shed is needed for each combination and the sheds tmemselves should be widely separated from one another to prevent fertilization of the female arrows with pollen other than the one intended. Sugar cane pollen loses its vitality so quickly under the ordinary atmospheric conditions that the same shed could with impunity be used for more than one combination by rolling out the top tarpaulin and fully exposing the shed to the action of the sun and air for a day or two by way of abundant caution. In practice, the opportunity to do the desired combinations comes at different periods, sometimes widely separated from one another, and the number of sheds needed would be much less than the number of combinations proposed to be attempted during the season.

IV. *The pollination is continuous and on a large scale.*

Once such sheds are put up and are properly filled in, the cross pollination goes on in the sheds with but little attention from the operator, except an occasional look round to see that things are actually progressing in the manner designed. The pollination continues for some days after the first setting up, the male arrows liberating fresh pollen each morning and the female arrows exposing a new set of stigmas as the arrows emerge and grow to their full length.

The above arrangement enables the carrying out of any desired cross pollination on a fairly large scale, as it provides for the simultaneous pollination of a large number of female arrows from an equally large number of male ones. It thus enables full advantage being taken of any combination which, through experience, has been found to be particularly promising in producing a desired type of seedling canes.

V. *Artificial bending of canes to keep shed at convenient height*

Till recently the artificial rooting on the canes intended for isolation used to be carried out on the lowest joints, as in this position, it is comparatively easy to set up the necessary apparatus for the artificial rooting. The treated canes were thus, practically as high as the canes in the field, with the result that the hybridization sheds had to be erected fairly high, higher than the tallest of the rooted canes.

The interesting work of Toribio Mercado in connection with the training of arrows for pollination work, has enabled the height of the sheds to be brought to within a convenient height. About a week previous to the time for placing the arrows inside the sheds, the treated canes with the pots containing the freshly developed roots are placed in a horizontal direction on the ground (Figure 23). This causes the top portion of the cane carrying the arrow to bend at right angles and become erect. After this bending the arrows could be accommodated in sheds of convenient height by keeping the pots oltside the shed and the canes converging towards the centre of the shed as seen in the picture of the hybridization shed (Figure 22).

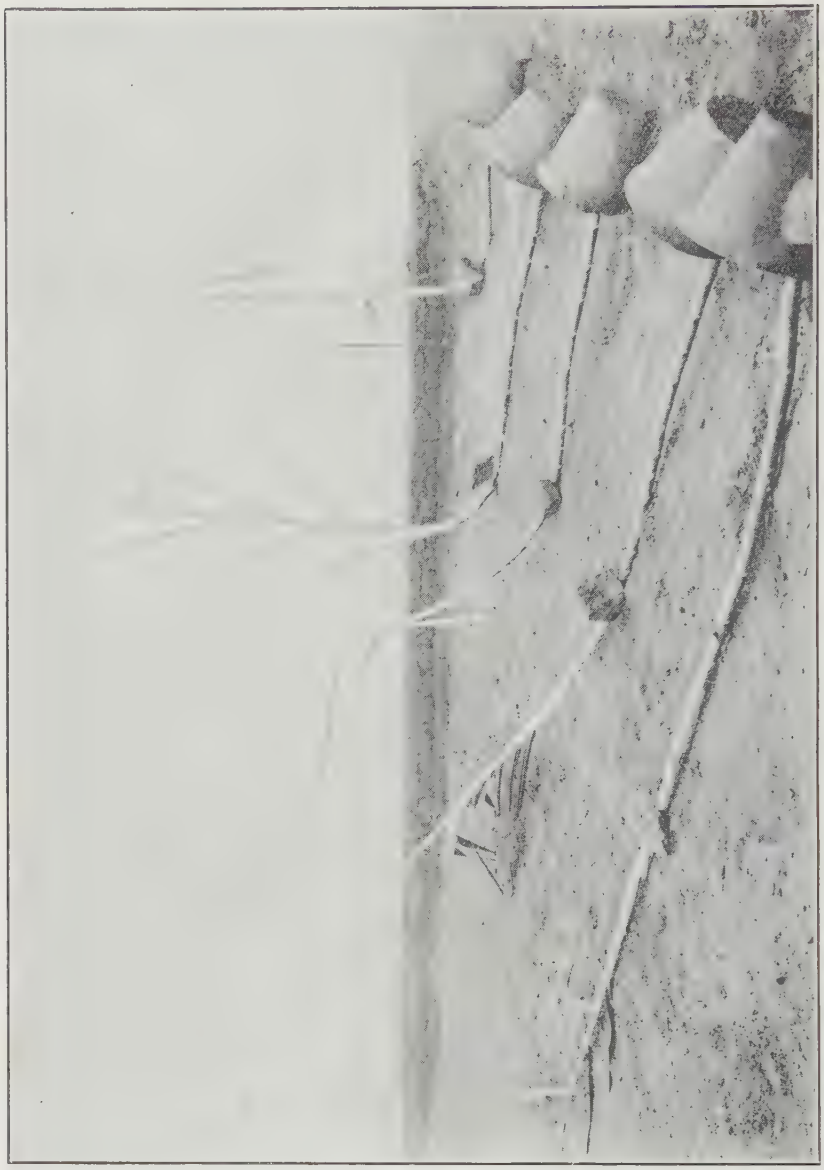


FIG. 23

Artificial bending of rooted sugarcanes to keep the arrows to within a convenient height for pollination operations.

VI. *Growing male parents in garden pots*

In the case of certain male parents even young plants flower as the arrowing season is on. With such varieties it has been found convenient to plant in garden pots setts of the variety five months previous to the arrowing season. When the arrowing season comes round, the five months old plants flower, three to four arrows being obtained from each pot plant and the plants with the pots containing them could be handled with considerable ease in the subsequent pollination operations. This arrangement has been found particularly useful for doing the cross pollinations outside the station and in fields owned by private individuals. The pots are hoisted on vertical bamboo supports and the position of the male arrows is adjusted to that of the arrows to be pollinated by a suitable pulley arrangement fixed to the bamboo supports. Figure 24.

FIG. 24

Hoisting sugarcane plants in the field for cross pollination purposes

THE VARIETAL REVOLUTION IN PORTO RICO

Submitted by Charles E. Chardon,

Commissioner of Agriculture and Labor of Porto Rico.

(This paper has been published in the Journal of the Department of Agriculture of Porto Rico, Vol. XI, 1927, pp. 9-41).

RAPID PROPAGATION OF CANE BY THE "SPROUT" METHOD

By Dr. J. Jeswiet.

As it is of the highest importance to try out as soon as possible the selected canes in fields on a factory basis in comparison to the standard canes, we tried in Java to propagate as quickly as possible in order to get a large quantity in a short time. For example, we had in August 1922 only the original seedling plant of No. 2878 and this year (1927) there are now 30,000 bouws in the factory fields. Moreover, all the nurseries are crowded with plant cane. This way of prapagation is described in the publications of our Station and was suggested by Dr. ph. van Harreveld.

As is known, every stool of plant cane produces more stalks then come to development in the later stages. This results from a shading of the shorter, slower or later growers by the leaves of the older, better stalks : The method of quick propagation is based on the desire that no sprout may be lost, that every sprout may be developed to a new plant. Therefore, all plants of the first planted part are carefully watched and every side sprout that has developed far enough to be estimated as having made its own roots is taken off from the mother sprout by cutting it a short distance above its insertion. Before this is done the soil next to the sprout has to be removed carefully in order to find the base of the young shoot. The cut is made with a narrow knife in order to do as little damage as possible to the roots. By leaving the basal part of the mother plant the lower buds are kept and may produce young secondary shoots which can be cut away after six weeks. In the time between these two periods of cutting there might be other primary sprouts old enough to remove from the mother plant and for this reason the plant has to be inspected every day. The sprouts have to be planted immediately in furrows near the first plot. Their leaves have to be cut a short distance above the leaf blade base in order to decrease the greater transpiration. The dry lower leaf sheaths have to be taken away in order to permit a quick development of the roots. When planted, the young sprouts are laid at an angle of 40 to 45 degrees in a straight line in the furrow but in two directions. This being done to prevent the mother stalk covering the young sprouts.

The planting on angle of 45 degrees is done to give a chance of sprouting to every basal bud and to be in such position that individual sprouts may be taken away without damage to the others. As soon as the sprouts are planted it is necessary to water them or to irrigate them frequently in order to keep the soil moist. After a period of about 6 weeks the new sprouts are developed and may be cut away just as the sprouts before for the original plot. They also are planted in other rows, thus continuing the work. The number of sprouts to be planted out every day will increase considerably. When the sprouts have been taken away from the stool twice

the plant is given additional fertilizer and soil. By cutting off the side sprouts the roots of the mother sprouts are more or less damaged and hence its growth is checked somewhat. By the high application of fertilizer and the fact that the mother sprouts are in full light from all directions, the buds are often developing into shoots. As soon as there is one of the younger sprouts large enough to replace the mother sprout, the latter is cut off and planted in pieces of two to three buds. This work is continued for about 3 to 4 months and after that the plant is given occasion for free growth for 2 to 3 months more. Then the whole field is cut, the younger sprouts are planted in the Station field; the well developed ones, about 3 to 4 feet high, are sent to the factories for trial and on the field itself the ratoons are cultivated.

A LIST OF THE SUGAR CANE VARIETIES OF CUBA

By F. S. Earle

(Mr. Earle submitted a list of the sugar cane varieties of Cuba which comprises a report of 44 printed pages, a copy of which can be obtained on request from the Cuba Sugar Club, Edificio Gomez Mena, Havana, Cuba).

THE FLOWERING OF SUGAR CANE

By Dr. J. Jeswiet.

When cane is about to flower leaves become shorter and straighter the sheaths being relatively longer. The highest leaf is called the banner. The tassel emerges from the highest leaf sheath as a cylindrical mass and after one day opens its branches, spreading them from the main axis and assuming a drooping habit. Upon the opening of the spikelets, the floweing begins at the top, progressing to the base and to the center. For further knowledge reference is made to the work of Wilbrink, Kuyper, Bremer, and Jeswiet. The characters of the flowers are used in classification. In every node of the branchlets of the tassels is a pair of spikelets, one of them is pedicelled, the other is not. When flowering, both spikelets of one pair do not open simultaneously and there is a difference by which we make two entirely different natural groups in the canes of the world as shown in the discussion of the genus Saccharum.

The members of the last species (only represented by the real sugar cane Saccharum officinarum L) are susceptible to many diseases such as Sereh and mosaic, and have as rule roots not as trong as those of the canes of the other species.

The three other species are resistant to diseases to a different degree. All three have strong roots as a rule.

Saccharum spontanum, L., the wild cane shows immunity against mosaic disease and Sereh disease, but is attacked by the smut. The type of *Sacharum sinense* Roxb. (Chinese and Japanese types) as a whole show immunity to Sereh disease; some of them are immune to mosaic and others are attacked by it. The types of *S. Barberi Jesw.* (Chunnee and other British Indian canes) are as far as is known immune to Sereh disease, but are all susceptible to mosaic disease. This grouping shows us that for crossing purposes we might prefer *S. Spontaneum* L. for its immunity and strong roots, maintaining itself in a wild state. Next to this are the immune Chinese types but they may have lost already some of their resistance as the result of cultivation, whereas the S. spontaneum, because it has never been cultivated, maintains its im-

munity characters fully developed. This is a case of the survival of the fittest according to natural selection.

HYBRIDIZATION OF CANE

As crossing work has been done on a large scale in Java, we wroked with canes not only of our variety plots but used also the best male parents of the cane varieties in the factory fields. Those canes have been selected on characters for field and factory abilities. During crossing time our motor cars go out to the fields in the neighborhood of the experiment station and the men trained for this work select given quantities of the best tassels of the field, out them with a rather long piece of cane attached and bring them to the crossing plots. The best tassels are those that are in the flowering condition for 3/3 of the distance from the top. This work is done at about 4 P. M. to give the tassels time to recover from the extreme heat of the day. The tassels are packed in thin mats of fibre and closed up in bamboo covers to prevent drying. At the station from every variety two tassels are placed in bamboo holders filled with water, labelled with the name and placed near the female plots in the field.

The next night the male flowers are bound to the females in such a way that the flowering part of the female tassels is covered by that of the two males and the tassels are not covered by bags. This work has to be finished before 5:30 because at that time on the average the pollen of the majority of the varieties is shedd from the stamens. As for nearly all varieties this occurs on the same time and as cane pollen holds its activity only for a short time, we may be sure that the pollen nearest, i. e., that of the male tassels brough to the female, has the best chance to be the first to pollinate and to give us the desired crossing.

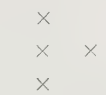
Because the crossings in Java are made to get immune canes we prefer our female canes to be crossings from the S. spontaneum L. blood. By so doing we know that every seedling descended from the pollinated tassel, is of the desired blood, even though occasionally there may be a pollination by other pollen than we wished. Experience, however, showed us that such cases of undesired pollination are a very great exception. Using no bags of cotton or paper the number of seedlings of each tassel is as a rule much greater than when working with bags. The bags are used only for controlling purposes and for the crossings needed for pure scientific work such as cytological and morphological studies.

This mode of pollination has to be carried out for as many days as the female tassel is flowering, usually 6 to 10 days. Every morning new male tassels must be brought. After the flowering of the female tassels is over, bags of fine mosquito netting are put over them while the seeds are ripening to prevent the ripe seeds being blown away by the wind and also to make certain that no seeds of other tassels become mixed with them. Ripening takes about three weeks after pollination has stopped. The crossing label on the stalk is then tied to the bag, the whole tassel with its bag is cut and brought to the Experiment Station. After one day for drying, the fuzzy seed is sown in square boxes $50 \times 50 \times \times 15$ centimeters high, filled with soil containing 1/3 horse stable manure, 1/3 silt and 1/3 volcanic sand. After $2\frac{1}{2}$ to 3 days germination begins. Samples that do not germinate within 10 days are thrown away.

From every new unknown combination only 100 to 200 seedlings are planted out in the field, so as to get an idea about the hereditary character of the parents as shown in their offsprings. Experience showed that this number was sufficient for

that purpose. If the combination is a good one, the same crossing may be made the following year with a larger number of tassels. Some thousands of plants may be put out on the field. Working on that basis saves time, money and work. After about one month the young seedlings are replanted from the boxes into pots and then from the pots to the field. The first selection in the field is based upon the combinations themselves at an age of about 10 to 11 months, about flowering time. Those plots showing undesirable characters as a whole are eliminated from the field book. Next to this selection follows the selection of the good seedlings within the remaining plots. This selection is based on habit characters, growing power, tasseling, etc.

Every selected seedling gets two labels with the letter of the year and the succession numbers, for example, in the sixth year of crossing F 122. These numbers are written in the field book behind the relative combination (F 122-126). After that time in the month of July the seedlings are dug out and brought to the testing mill. Here there is another selection on habit of growth, for example, sprouting of the eyes, bending of the stalks, and above all on the characters of the interior of the stalk; if is is dry or hollow a seedling is rejected. Only those that are solid and juicy are kept. Then follows the test in the mill. Only two factors are considered: Brix and Polarization. All of the seedlings below a certain point in either case are eliminated . The few which come up to the desired standard of brix and polarization or that are higher than this are kept. The top quarter of every seedling is cut off before milling and each part gets one of the two labels which are put on in the field. From the selected ones the tops are planted in the field under their number of that year in one to three rows. Only from the very best ones are three rows planted. At the same time some material of these best ones is planted in another place and they are propagated as rapidly as possible by the van Harreveld sprout method. This method teaches us much about the sprouting capacity, quickness of growth, strength of roots. Those that win the race, that is, those that fill up the available space equally open to each of them are taken under close observation. In the rows of the collection the cane grows up to mature ripe cane and notes are made about the development, in the field books. In the month of May and again in the month of July and analysis is made of five stalks to learn if brix and polarization are up to the same standard as in the first year. An allowance is made for the climatic conditions of the year. Those canes which are far below the standard of the first year are rejected. In the 3rd year the selected numbers are planted on the south and north sides of a path and the southern plot gets 2 times as much fertilizer as the northern plot. This is done to study the reaction of the canes to a larger quantity of fertilizer. Analyses are made from each of the plots 4 or 5 times at fortnightly intervals to learn something about the ripening and how long the ripe stage will continue. Those varieties that show up the best are then sent to the factories in small quantities to test them under the same conditions as the standard canes of the factory. These trials are merely preliminary ones. They consist of a block of 25 to 30 rows compared with 4 adjacent blocks of the standard variety.



If these small trials give good results the next year trials are started on a bigger scale with 12 plots of 30 rows each in comparison with 12 alternating plots of the standard factory variety (Literature; Archief J. S. T. Geerts—Kuyper). If the

variety in a great many of these trials is the winner, it is propagated for larger areas and comes into field culture. By this method in five years a seedling can be brought into general cultivation.

CHARACTERS NOTED IN THE FIELD

1. Length. 2. Flowering. Early flowering and abundant flowering stops growth at that time and the sugar of the upper part of the stalk is used. 3. Form of stalks (no zigzags, no bent stalks, stalks not too conical). 4. Habit of stool (all stalks regularly developed and upright in the stools.) I. Simultaneous developement of stalks, not earlier development of the mother stalk. 6. Thickness (too slender stalks are rejected; in very thick canes there may be trouble in leaf development) 7. Form of internodes (cylindrical ones are preferred) barrel-shaped and very thick internodes are often too brittle). 8. Adventitious roots sprouting on the stalks (stalks must be clean); 9. Habit of bud (depressed, closed buds; not sprouting); 10. Forming of suckers early and too heavy and too much after flowering; 12. Tillering must be sufficient, seedlings with one or two stalks are not accepted; 13. Habit of the leaf. Not too broad and not too long because the very heavy top or crown makes the cane close in too early and affects the number of stalks. Self-trashing is preferred.

CHARACTERS IN THE FACTORY

Lay the plants close to each other on the same base line; criticize once more some of the above named characters such as relative length, thickness, buds, uprightness, etc. Moreover, cut the cane 1/4 from the top and study the central tissues. If the pith is dry or hollow the cane is discarded.

CONDITIONS FAVORABLE FOR FLOWERING

An oceanic climate in the mountains of the equatorial region with rain well divided over the year is suitable for the good growth without a growth-check. Rain and sunchine are necessary in the crossing season; all groups of cane should flower at the same time and each variety over a long period. It the weather is too dry the flowers may develop, the pollen may be good, and only a few seeds be ripen. I give as an example the year 1916 and 1917. Cane was planted in July with irrigation; rain began in August 1916 with one day of rain; September 1st, rain; October 10 days; November 19 days, whereupon the wet monsoon regularly begins; in March 1917, 19 days of rain; April, 20 days; May, 5 days. Most of the tassels from April and March gave thousands of seedlings; from those of May very few were secured. In 1918 it was dry in the flowering season and from the same crossings which in 1917 produced thousands of seedlings, we got only 5 or 10, that is a very small number. Now we have our fields for crossing in Malang, thus opening all possibilities for suitable conditions.

Plants along drains flower earlier; plants with root troubles also. Sexual cells die by bad circumstances. The same variety which in rainy weather is hermaphroditic and fertile may be sterile or only female in the dry time. A tassel of Ardjoono cane from Malang (500 m. above sea level in the rainy region) gave us about 6,000 seedlings; one in Pasvervean about 100 seedlings in the dry season. In some places the vegetative period was too short in our culture fields. Salak Borneo, a cane that never flowered before, produced flowers regularly for over several months

on many of the stalks when left standing more than one and a half year. The great influence of circumstances upon flowering and sterility became evident in 1925 when the black Cheribon, always an absolute mother cane and without pollen, gave an abundance of pollen in Malang and was even used as a male parent in crossings. Some of the other canes retained their female characters, i. e., Lahaina, 100 P. O. J., 2364 P. O. J., 2722 POJ.

Yellow Caledonia, Red New Guinea, 36 POJ, 2714 POJ remained completely infertile.

POLLEN TEST

The iodine test for every variety should be made more than once during the season.

Germination of Pollen.—The germination of pollen was tried in many solutions by van Breemen but without success. I tried it on the stigmata of the female flowers in my laboratory. The newly opened spikelets were pollinated. In the course of a morning the results were visible under the microscope.

Methods of Crossing.—A. *Without castrating,* taking the female variety.

1. As described with free tassels.
2. As above described but in bags of drill.
   In both cases with male flowers brought to the female ones.
3. Bending together male and female flower on the living plants.
4. By gathering the pollen and blowing it on the stigmata in cases of few tassels.

B. *Castrating.*

1. Pollinating with a small brush.

SELECTION OF THE SEED PLOTS AS SUCH

This is begun before the rainy season to determine whether the cane can stand a dry atmosphere; if there are any cases of weaker root system which might not show during the rainy season, they are more clearly demonstrated when the drouth sets in. The flowering capacities of the desired combinations should also be noted. The length of flowering should be compared with other plots of the same blood but of different parentage. Selection of seed plots is made to learn the hereditary qualities of the parents. Therefore, the same mother variety is used in crossings with many male varieties.

Selection has to be made under favorable conditions.—On good soil and under good conditions many cane varieties do well, which under less favorable conditions die off or show weak characters. Cane selected under unfavorable circumstances have a better chance to succeed under different conditions. Never select on the best soil.

WORLD MATERIAL OF SACCHARUM

By Dr. Jacob Jeswiet.

The genus Saccharum was in my last work in 1926 freed from the ballast added to it by Hackel in his work "Andropogoneae". Hackel added so many other genera and species of other genera to the genus Saccharum that the diagnosis he gives is overloaded by characters and the reverse of these characters as such. Thereby he derives the description of a sharp contour, necessary for the positive description of a genus.. For example: axes of the branches *brittle,* seldom *tough;* spikelets in

pairs, seldom *alone;* secondary spikelets *sessile,* seldom *pedicelled;* both spikelets *hermaphrodite,* seldom the pedicelled one *female;* foutrh glume crowned by a small awn or *not so;* spikelets on the small callus with long hairs (seldom also on the back of the spikelets). He had to do so to take up 4 former genera as sub-genera in the genus Saccharum.

The subgenera are: 1. Sclerostachya, including Saccharum Ridleyi and Saccharum fascum Roxb., characterized by tough axes of branches in ripe tassels and *pedicelled secondary spikelets* and *hollow stalks.* This has to remain a genus to be placed in the neighborhood of the genus *Miscanthus* and the genus *Imperata.* Thereby the genus Saccharum is already better defined and freed from the reverse characters such as tough axes, pedicelled secondary spikelets and hollow stalks.

2. *Eriochrysis* characterized by hollow stalks and by the female character of the pedicelled spikelets, and by these characters diverging from Saccharum. Moreover by its geographical distribution. All the species of the genus Saccharum are to be found only in the old world, but this genus is to be found in 3 species in the new world (South America) and one in Africa. Hackel himself says, that Eriochrysis is a subgenus, with the value of a genus. With these contrasting characters it is better to take it out of the genus Saccharum.

3. *Leptosaccharum* characterized for example by the fact that the spikelets are alone on the branches and the halms are hollow. Moreover one, not well defined species from South America Hactek assumes that he might have made a genus out of it, if all material he received had not been so poor, than in better developed specimens there would have been 2 spikelets at each node. This is not true. Very poor, dying samples gave me always paired spikelets in Saccharum. By taking these three subgenera out of the genus it is freed from the four following controversal characters: spikelets single; axes tough; secondary spikelets pedicelled, primary spikelets hermaphroditic.

The fourth subgenus was named by Hackel *Eusaccharum.* In this subgenus we find the species Saccharum officinarum I. and S. spontaneum L. Moroeover many species characterized by long hairs on glume I and by the bearing of a little awn by glume IV; these are Saccharum arundinaceum, S. ciliare.

These two and S. Munja have to be brought to a subgenus of the genus Erianthus, for example, in the hairs behind the ligule, lack of triangles at the blade base, rough axes on the tassel and the very short callus hairs, shorter than the spikelets. Therefore, they become Erianthus arundinaceus (Rey) Jesw. Er. ciliaris (Anderss Jeswiet, E. Munja (Roxb) Jesw. S. Narenga, characterized by thick leathery glumes and very short floral leaf, might be given a place as a genus by itself.

By studying this revised genus Saccharum I found that the material conforming with the characters of Saccharum could be made into four natural groups as follows:

A. Main axes of the branches with long hairs, always 4 glumes. In the spikelets of one pair do not flower simultaneously, the pedicelled one is the first. Stalks green, grayish green, bronzegreen, ivory.

1. Lodiculae ciliate; long subterraneum stolons growing in a wild state. . . . . S. Spontaneum L.

2. Lodiculae not hairy, stolons short, cultivated plants containing sugar.

a. Leaves up to 5 centimeters broad, long bronzegreen stalks, swollen nodes. (Uba type, Japanese canes) . . . . . S. sinensi (Roxb) Jesw.

b. Leaves narrow (up to 2½ centimeters) short, slender canes, cylindrical stalks grayish green to ivory; originated from British India (Chunnee type; Uba canes). . . . . S. barberi. Jesw.

B. Main axis and branches smooth, never long haired, 3 glumes, seldom 4, Lodiculae not ciliated.

If the spikelets of one pair de not flower simultaneously, the sessile one flowers first. Stalks have vivid colors from red to green and yellow, leaves red or green, cultivated plants. . . . . Saccharum Officinarum L.

1. Fourth glume present. Most gigantic, hige forms, low in sugar, Fidji, Ardjoens, Green Guines cane, etc.
2. Fourth glume lacking. More tender forms; Rich in sugar, Cheribon, Batjan, Borneo, Lahaina, Cristalina, etc.

THE SULPHUROUS ACID METHOD IN CANE BREEDING

By H. P. Agee

In the early years of seedling propagation in Hawaii field crossing was depended upon to supply the planting material. However, the number of combinations which it was possible to obtain by this method was limited, and the need for a method of artificial crossing began to make itself felt. The Java method of cutting the male tassels, placing their cut ends in water and tying them in such a position that their pollen would fall upon the stigmas of the female tassels proved workable, but not altogether satisfactory. The life of the male tassels in water was found to be very short,—rarely ower 2 days. This necessitated a large supply of male tassels, often difficult to obtain, and the expenditure of a great amount of labor in replacing the spent tassels with fresh ones.

Experiments were therefore begun by the Agricultural Department in an effort to find some means of prolonging the period of effectiveness of the cut male tassels. It was early observed that there was a rapid increase in the bactrial flora of the water in which the stalks were kept and that the walls of the container as well as the cut end of the stalk was covered within a few hours by a layer of slime. It was also found that cutting off at least one internode each day and frequent changing of the water in the container prolonged the life of the tassel quite considerably.

These observations suggested that the early withering of the cut tassel resulted from a clogging of the vascular system by micro-organisms and that this difficulty might be overcome by an antiseptic lethal to these organisms but not injurious to the tassel. Hundreds of chemicals in various concentrations were accordingly tried. Several of these were found to have slight beneficial effects, but only,—a .03 per cent solution of sulphur dioxide* in water was found to be efficacious enough to be of use.

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* The sulprur dioxide is purchased in metal cylinders. A 3 per cent stock solution is first made by bubbling the required weight of the gas into water. This is diluted for use by taking one part of the stock solution to 99 parts of water.

These experiments were carried out for the most part in 1924, and the sulphurous acid solution was first tried out on a field scale during the 1924-1925 crossing season. It was found that the make tassels kept in the solution remained alive

and fresh for several weeks, the blooming and pollen shedding proceeding to completion in much the same way as in the uncut tassel.

Subsequently it was found that the cut tassels in the solution matured viable seed. The possibility of cutting both the male and female tassels and placing them together in the solution in a situation completely isolated from all other tassels suggested itself. This method has been tried out on a fairly extensive scale the past season and excellent germinations were obtained.

Should the results of the coming season bear out the promise which this method appears to hold, the obtaining of desired crosses under conditions precluding the possibility of outside contamination will be greatly facilitated.

The possibility that some of the seedlings resulting from the use of this method may be selfs rather than crosses is not precluded when the variety used as the female parent also produces pollen. The proportion of selfs will depend, of course, on the amount and viability of the pollen produced by the female and by the degree of its self fertility.

It should be possible to obtain information as to the extent of selfing in individual cases by isolating some tassels of the female in question and determining the amount of germination obtained without the intervention of the male tassels.

This project of using sulphurous acid in cane breeding work was developed by Mr. J. A. Verret assisted by Messrs. Kutsunai, Das. Conant and Twigg Smith.

PROCEEDINGS OF HAVANA CONFERENCE

SECTION V.

CULTIVATION AND FIELD OPERATIONS (INCLUDING SOIL MANAGEMENT AND USE OF FERTILIZERS)

H. F. Clarke, *Chairman.* J. A. Faris, *Secretary.*

Classification of Soils. *By R .V. Allison.*
Fertilizers. *By Oswald Schreiner.*
Preparation of Land. *By F. S. Earle.*
Cultivation in Cuba. *By J. A. Faris.*
The Cultivation of Ratoons in Cuba. *By R. Menendez Ramos.*
Varieties Cultivated in Formosa. *By Migaku Ishida.*
A Discussion of Fertilizers, Cultivation, Treatment of Seed and Conservation of Moisture.

SECTION V

Cultivation and Field Operations

(Including Soil Management and the Use of Fertilizers)

General Session, March 18, A. M.

Dr. R. V. Allison of Florida presented a paper on the Classification of Soils.

(Abstract)

In giving adequate consideration to the broad agronomic problems that are found to arise from time to time in connection with the production of sugar cane in any country, the present committee on cultivation is disposed to believe that matters pertaining to the judicious selection and treatment of the soil should be regarded as of foremost importance at all times.

In considering in this way the active relation of the work of the soil technologist to that of other scientists responsible for the health of the plant, its protection from insects or any one of a number of other definite responsibilities, the thought is turned to the extraordinary cleverness displayed in the preparation of the title, by Sir John Russell for that most remarkable book "Soil Conditions and Plant Growth". It is seen how the latter falls in a most natural way to a position subordinate to the former. If the failure in cane production in many parts of Cuba, and I dare say of many other countries, be examined critically, this subordination of plant growth to soil conditions will find emphatic illustration.

It is believed that when the importance of the relation of soil type to plant development is given good consideration, there have been discussed in this Congress few topics, intimately related to the production of cane in the field, that fall beyond the scope of correlation with this factor.

The fact of extreme variability in soils from place to place has been recognized for many years. It is only within comparatively recent times, however, that a system of classification, based upon type definition and differentiation, has been developed which holds forth promise of permanent service and definite continuity of type delineation from region to region, state to state or nation to nation.

At the present time, however, in practically all countries where permanent progress has been made in agricultural experimentation, the idea of soil classification upon the modern basis is rapidly forming for itself a strong and enduring place and in not a few, notable progress has been made in the preparation of soil surveys over broad areas.

In connection with the present congress it was thought appropiate by the committee to mention in a very brief way the general character and findings of the recently completed reconnaissance soil survey of Cuba that has been carried out by the Tropical Plant Research Foundation.

It is to be regretted that Mr. Bennett, who represented the Bureau of Soils in this work, found it impossible to attend this Congress. The fact of his long experience in the classification of the soils of the southern states, as well as his extensive tropical experience as soil expert with the U. S. Rubber Expedition through Latin America, has made it a most fortunate circumstance that, through the generosity of the Departament of Agriculture he was able to undertake this work in Cuba. For the information of those interested in the soils of the Latin American countries covered by the expedition referred to, it might be of interest to note that the report of the Commission has been issued recently by the Department of Commerce.

In referring to the matter of the survey briefly, it may be well to emphasize that the purpose is rather to illustrate the type of approach and the usefulness and importance of soil type delineation in general rather than to discuss Cuban soils in particular. In other words it is desired to emphasize the fact of soil variability and the procedure to be adopted in meeting the problem on a broad scale with the hope that the subsequent discussion will orient itself as much as possible with respect to particular soil types and conditions rather than deal too largely in generalities in this respect.

In this work the unit of treatment has been the soil series of which nearly one hundred have been described. These, for convenience of treatment, have been grouped into about fifteen families, a grouping that has been made for the most part upon the basis of rather broad differences in physical properties.

The series description itself is based upon an examination of the entire soil profile and particular consideration given to color, structure, prominent chemical features, presence of hardpans (Clay pans, gravel, sand beds, desintegrated rock, hard rock, etc.) arrangement of horizons, drainage, parent material, etc.

For the purpose of general discussion the whole island has been divided into three general parts, the Eastern, Middle, and Western, and these further divided into sections and the soils of each section discussed in some detail .

By way of illustrating the agricultural relations that may be built up about systematic soil types or groups of types, three diverse soil families might be briefly considered in relation to the single point of deep cultivation. I. The Matanzas family, consisting of soils practically homogeneous to any depth, highly permeable and non-plastic, may be plowed to practically any depth, though it is doubtful if deep knifing will prove particularly advantageous. II. The Truffin Family, commonly represented by a reddish-brown to brown clay in the topsoil, has a characteristic property upon drying, an extremely hard to almost rock-like condition in the subsoil. This material is usually found to consist of clay of such a nature that it shatters or fragments in good shape, and is tremendously improved by knifing. III. The Bayamo Family, consists largely of heavy, plastic clays, however, and knifing to any depth cannot be done with any assurance of benefits at all permanent because of the tendency of such soils to flow back together upon the occasion of the first heavy rain.

Aside from the physical and chemical analyses for the purpose of type delineation, considerable study also has been given to the chemical nature and occurrence of concretionary material, the reaction of the broader types, and the measurement of some of the more important of these for special physical qualities of importance in determining their erosive qualities and their possible realtion to highway construction. Such special chemical features as high salt content has also been given particular attention both in relation to its effect upon cane development and the proper and economic handling of such saline soils.

Once the seriousness of soil variability is appreciated, an almost infinite series of applications could be mentioned, and while the survey which has been referred to so briefly was originally inaugurated as a basis for the study of the more purely agronomic problems such as varietal adaptability, fertilizer requirements, etc., it is readily seen that its further usefulness as a basis for research in a great number of allied fields should serve, somewhat, to expedite its application upon a more detailed basis.

Dr. Oswald Schreiner.

Mr. Chairman, you have assigned me the topic of fertilizers, and fertilizers, I take it, in their application to field experimentation. Much has been said in these meetings about diseasses, and it is rather interesting to note that the work which we have been carrying on fertilizers had its origin in exactly that, in the diseases of plants. The manifestation of diseases, either by the action of organisms or by internal disturbances in the plant, socalled plant physiological diseases, were the origin really of our work in the field. Our early work, as some of you may know who are interested in soil wark, concerned itself with the fundamentals of soil fertility, and in that study, when we first began the inquiry, we took up the question of humus, and we soon found out that we knew nothing whatever about humus except that it is a green plant plowed under, or dead plants which have fallen and

gradually gotten into the soil, but we knew nothing definite of its chemical composition. We tackled the problem of finding out what is the nature of this humus, and in connection with that study we isolated from the soil a great many organic substances. That is, we went at the soil just as the sugar chemists have long done with sugar, in isolating sugar from the sugar cane plant or juice. We actually crystalized out a large number (now approximating more than fifty) of definite chemical compounds. We studied these chemical compounds then, in their action on plants, whether beneficial, whether helpful, or whether inert, and to make a long story short, we found some of them were beneficial directly, furnishing food to the plant by the assimilation of these organic substances. We found that some of them were harmful, causing root difficulties, root diseases and the killing of the roots. We found that some of them were inert, because in a great measure they were locked up. Now the question came up: what is the action of the fertilizers on these organic materials?

What is the action of these substances on plants that are growing. Now in order to do this we use the water cultures and use different plant foods in these water cultures and then apply these substances in these water cultures along with those various chemicals, and in doing that we struck what would appear at first sight to be a very elaborate and intrincate scheme, but which later we were able to carry successfully even into the field, and is now culminated in a system of study of fertilizer experiments in the field. Our first excursion into field work was in connection with one of these so-called plant degeneration diseases. We were at the time working in Maine, a good way from here, in connection with potato plants. We went up there to investigate certain matters in connection with the powdery scab of the potato, and we placed there to investigate this trouble some of our men, a soil survey man, a chemist and a plant pathologist, and while they were up there, it was in 1916, there broke out in Maine a new disease, and I went up to find out something about it. It seemed to be causing considerable difficulty; it seemed to appear suddenly, broke out in a field and then spread through that field just as any disease would. When I arrived there the plant pathologist took me aside and said with the enjoyment which a plant pathologist so often finds in such things: "I have found a new disease". One of my men took me aside on the way up to the laboratory and said: "Do not take too much stock in that fellow's new disease until you see my results. I have been analysing these soils chemically, and I find that everywhere where that disease is they have more nitrates than where the disease is not. I think it is chemical; I think it is due to the nitrates, and I find that they are using more nitrates in their fertilizer. (This was during the war, you see). They have cut out the potash and they are putting in a little more nitrate to make up for the potash that is not in there, and I find that this increased nitrate is the cause." Then the soil survey man got in and he said: "Do not take any stock in what these fellows are telling you. I have got the real answer about this. I have been going into the fields while these fellows are working in the laboratory. That disease occurs on only one soil type. It never occurs on any other soil type. (There are two principal soil types in Maine) it occurs only on one soil type and on no other". And do you know, when I looked into it every last one of those men were right. The plant pathologist showed me specimens of diseased plants in the field and his cross sections in the laboratory. I might add here that later on he found that he had too many organisms. But he made good on the disease. And the chemist, of course, made good upon his analysis which could not be doubted; he certainly had

more nitrate every time on the diseased plants as compared to the healthy plants. And the soil survey man absolutely made good too, because he certainly could show each time the limitation of the disease where there was limitation of the soils, and that was in harmony with the results we had reached with the powdery scab also. The disease was confined under certain rainfall conditions, always to one soil type, and the disease instead of being one of major significance became one of minor influence in the potato world. Pretty soon then, as that went along, the thing revolved itself into this: that this condition is really potash-lack developed as a result of the scarcity of that ingredient during the war. It did not show itself the first year or the second, but by the time the third year came the potash breakdown occurred and the plant suffered from that. Now, how shall we prove it? We went at it, amd it occurred in this way. We introduced the system of treating the soil by fertilizer experiments, with a very high additional quantity of fertilizer; from no potash to very high potash; in fact to all potash; from low nitrate to high nitrate, and from low phosphates to very high phosphates. And in a single year, in a single experiment, you might say, (we made several it was not a single experiment absolutely) proved to everyone, and it has been confirmd ever since, that it was due to potash-lack; and yet, if we had gone at it from the point of view of the pathologist alone we would have had a new disease for several years. The potash famine took place in Long Island, and in Long Island it was a different disease from that in Maine, and they had a quarrel about it. Of course, it was an infestation due to potash-lack. Now if we had gone at it experimenting as a plant disease, we would have gotten that result, but there is no doubt that the disease of the plant was due to potash-hunger. Like-wise, if we had gone at it as a fertilizer problem we would have proven our point. We did this as a matter of fact, but we planned our experiment so that it covered all these difficulties and the answer was potash-hunger and the way in which it was done is the principle that I wanted to describe now in brief, because I feel that in a conference like this if we can present to you a new scheme to approach a problem you will benefit more than you will illustrate the plan of our experiments: (Fig. 26)

We made our experiments using the three principal commercial fertilizer materials: ammonia, phosphoric acid, and potash. We arranged our experiments upon a triangular basis, the points of which represented the maximum amount of the various fertilizers used. The amount of any particular fertilizer material diminished as the other two points of the triangle are approached. This diagram will serve to illustrate the plan of our experiments:

Now we have 0 potash there (C) and all potash here (A). A fertilizer contains 0 potash here (B) and 20% here (A). There is a gradation along the line in number of points, but I shall use fifths, dividing in ten equal parts. Now here will be 4%, 8%, 12%, 16%, 20%. That is potash you see. Now if on the other hand we have ammonia: I am taking the principal fertilizer. At (C) we have ammonia. We have first ammonia here (C) 4, 8, 12, 16, 20% ammonia there. Now that means that anything along this line (A-C) point like this (C-2) contains 16% ammonia and 4% potash, and so on any point whatever along here will represent the position of a fertilizer in ammonia and potash. Now if on the other hand we take another point up here and draw a line here to six, P_2O_5, which is our fertilizer symbol for phosphate, and we have similarly the same relation here with ammonia and phosphate. That is, we have increasing phosphate this way (B-5 to B) until we get to our 20% and then we have increased ammonia this way (C-5

—C). If we again deduct our fifths we have something like that. Now this line gives a similar relation of phosphate and potash. You notice that in this line here (A-C) there was absolutely no phosphate whatever, but you see at this point here (B-5) there is four percent phosphate. Anywhere along this line (B-5) here is 4% phosphate. Anywhere along this line (B-4) here there is 8% prosphate. Any-

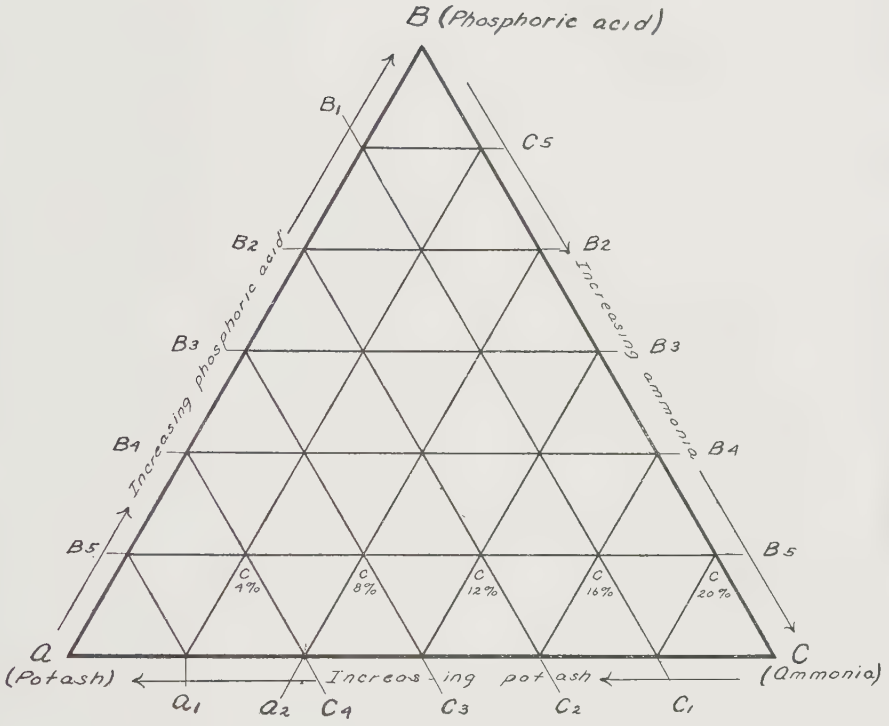


Fig. 26

Schreiner triangular plan of fertilizer experiments.

where along this line here (B-2) is 16% phosphate. Similarly, you will notice that there is no ammonia in this line here (B5 - Al - C5 - B). Similarly here, (C - C1) no potash; (C1 - C2) 4; (C2 - C3) 8; (C3 - C4) 12; 16; 20%. Now if we take these actual point like this, and this, and this for the preparation of our fertilizer for experimentation, we could take in intermediate points, but suppose

we omit those. Now we can prove that the fertilizer mixture represents each of these points. And we can lay them out in the fields, and we can cover in every possible combination, but because there can be many combinations in between, we have the whole field covered. This is the type of experimentation which we laid out in Maine with the potatoes. Now you notice that it is here and here and here, six of them, that contain no potash. Now when this test occurs in the field it is not arranged in a triangle. In the field they are arranged as follows:

A check plot; then No. 1, No. 2, No. 3, check; 4, 5, 6, check; 7, 8, 9, check. Now what I want to call your attention to is this, No. 1 will contain no potash. I will check that so it will be clear to you. No 3 again contains no potash; then again 6 contains no potash. Now the next no-potash will be No. 10 and so on. It was a very clear indication at that time, because you could see a half mile away that it was the plots that had no potash that caused the difficulty. The difficulty, on the other hand, was worse where you had the most nitrogen; therefore, study it from the nitrogen viewpoint; you attribute it to excess of nitrogen when it was really lack of potash. Now I mention that only to show you that we solved that problem there with practically the first shot out of the cannon and subsequent years proved it very nicely. Getting the boundary line of the two soil types right into the plots we find this difficulty on one soil and not in the other. Now with that as a start we went into the field work with other crops and other problems, and we are now working with the sugar cane in Louisiana along these some general lines. We are laying out fields there, studying this question of the action of chemicals, not only to determine the materials needed but also what is the best proportion of phosphate, potash and nitrogen in the growth of the sugar cane crop in Louisiana and under Louisiana conditions and soils.

Now in the handling of the problems, I want to call your attention to one thing—that you are not dependent on any one plot, and that is the beauty of the scheme. You are not dependent upon the results of any one plot. In any fields there are variations due to soil conditions; although we survey them most carefully, still there are soil conditions which most careful survey could not discern. It may have been twenty or thirty years before that they burnt the trash and still the plants feel its effects; you have this difficulty and then you have climatic conditions; and sometimes a disease will take one field or another, or insects or things that you cannot control or keep out. Now you are not dependent on that. If it is a phosphate requirement in your soil you have a whole lot of plots here that you can add all together and get the average. Or you can add up this lot and that lot, see what it shows for potash; you can add up this and see what indication you get for ammonia; add up all your fertilizers high in ammonia or your fertilizers high in potash; here, all your fertilizers high in phosphate, and compare these, or all six of them together. They are perfectly comparable, because each variation is the same in all instances, so they are perfectly comparable to add together and get an average. Now in all the sugar beet fields of Colorado, Dakota, and Nebraska we are getting remarkable results from this scheme, indicating a very high phosphate requirement. There, in Colorado particularly you may know or have read, they have a great deal of nitrate in the soil. We got out there with the idea of counterbalancing that, and, of course, this helps, if anything, to kill out the plants still more. On the other hand, this is what we expected would turn out, but it did not; it is a very high phosphate. On the other hand, on such crops as celery we have gone in and found a very low phosphate requirement and a very high potash requirement and

nitrogen requirement. The greatest growth is right in that region there. Add in sugar cane thus far, as the indications in Louisiana are working out our best requirement is perhaps a very high nitrogen. Now when you know that you are on the right track to a solution of this kind, then you can narrow your triangular experimentation. You can take only this entire section. You can work these more in detail here. Taking fertilizer combination in between that, and finally, if you wish, you can take in one of these smaller triangles and study it in great detail until you have arrived at the right formula for the right requirement.

Question: "You mentioned that in Louisiana you needed a high nitrate fertilizer. Do you mean for vegetative growth alone or did you take into consideration the sucrose content of the cane?"

Mr. Schreiner: We analize the sugar cane for sugar and find that the sugar per acre will be more in this region, and that, by the way, has also been our experience in connection with the sugar fields thus far. The sugar content is very often misleading; you will get a high sugar content sometimes in the individual plant, but not in a plot.

Prof. Earle: I want to say just how interested I have been in this talk this morning, because it so completely confirms the position I have long taken that in such diseases as sugar cane root rot environmental factors were controlling ones in many cases; that the parasites, while important, were perhaps incidental to the soil conditions, and I wish also to call attention to the class of experimentation made in Alabama many years ago by Dr. Atkinson, in which he demonstrated beyond a doubt that potash had a great deal to do with the control of the cotton leaf blight or rust, as it is called. I followed Dr. Atkinson in the experiment station in Alabama, and his results seemed so important that I repeated them in order to convince myself that he had not been mistaken. I went after all these problems from the mycological end and it seemed a little strange to me that a little potash would cure a big disease. I repeated the experiments, unfortunately not on the elaborate scale that you just illustrated, but enough to absolutely convince myself that potash application did cure leaf blight on cotton, and furthermore, I found that a heavy application of ammonia to the leaf or a combination of the two is much better than either alone, whereas phosphoric acid had absolutely the contrary effect. The potash plots dropped the leaves earlier and more completely than the untreated plots. The point seemed to be that the phosphate hastened maturity and the leaf maturing was more susceptible. Now here in Cuba my experience is very clear that phosphoric acid is very often the limiting factor in this, and contrarily the lack of phosphoric acid is the cause of many cases of your diseases.

Dr. Schreiner: Prof. Earle will probably be interested to know that we have tried out this on cotton and that the rust that you speak of is potash hunger. The rust is a symptom of potash hunger. Not only that; the pickers will object to picking that cotton because you can hardly pluck it. Whereas, with the potash you get a fine fluffy cotton. And it was absolutely shown in this that Dr. Atkinson was correct. And the same is true of diseases. We have taken for instance the cotton plants from plot Number Six here and from one that contained potash, which will be "five" right here. One has a leaf-like and fine flower; you can roll it up, spread it out again, and it is nice and smooth. The other is mottled with the disease, rusted, and it crisp, so that the moment you try to crush it into your hand it breaks into pieces, so striking is the difference. So you see the influence of many of these diseases.

Dr. Lopez: (Porto Rico). I wish to say that we are using these methods that Dr. Schreiner has explained. We have found out that fertilizer is one of the primary questions in sugar cane culture in Porto Rico. The soils are old; they have been cultivated for a very long time, and there is no possibility of getting a crop of cane without adequate fertilization. Considerable sums of money are spent every year on these fertilizers. With the experimental work carried out by the Department of Agriculture, everybody has become very much interested in the question of fertilizers, especially the application of our fertilizer law has been a great factor in awakening the people to the necessity of not merely applying the fertilizer, but of applying it as wisely as our experience will permit. As a result, we obtained numerous requests from all over the island for advice as to what fertiliezr to use in one region or in another, an dwe were confronted with the problem of having to advise these people, and had to find some way of advising them, that is, to the besa of our ability. Hence the necessity of experimenting along these lines, and we have been hard pressed by the people to do it. After attempting a number of experiments in the ordinary way, in the way in which they were usually conducted, which is to make experimental plots somewhere more or less in a test way, and cutting the cane and weighing it, we thought that the method was very inadequate, and that the results were very unsatisfactory, and when you came to interpret these results you would find yourself confronted with very conflicting figures from which it was very hard to get any conclusion that was worth anything at all. So we have now started to carry out experiments following the methods explained by Doctor Schreiner and we are doing it by not only establishing one single experiment in one single place, but we have established a chain of experiments all over the Island. Each experiment is on one type of soil which represents the region, so as to be able to cover all the different soil types, and all the different climatic conditions that may be present in the Island. But we have wanted to go forward and make as possible that we get our results and will be able to draw conclusions. So, in our experiments each combination we repeated at least five times, if possible ten times, but allowing for the difference in the soils. Now we are taking advantage of these experiments for determining another point that has been greatly debated in soil chemistry, and that I think is not settled yet. Just what method of analysis is to be used when you want to get an idea of the composition of your soil that may help you in selecting a fertilizer, and when you come to this you come to a very difficult point indeed. If you use the 1% citric acid method which is used in Hawaii to a great extent, and which we have been using, the citric acid will give you, (at least it is giving in our case) results that give you some sort of idea about the fertilizing requirement, but you will find that in different soils, it is different. That is, we have some soils that have more lime than others, and in those soils that are high in lime you usually get lower results than were to be expected. It seems that the lime in the soil reacts on the citric acid and affects the strength of the citric acid, and that is a factor that must be taken into consideration. What we are doing now is in each place where we have started one of these experiments, we take samples carefully and try to make the samples as representative as possible, and then we subject these samples to analyses by four different methods: by the total fusion method as recommended by the Association of Agricultural Chemists, by hydrofluoric acid, by nitric acid and by citric acid. The idea then is that after we have enough results from these field experiments, to try and see if we can establish a correlation between the analytic results and the results obtained in the fields by

means of these experiments. And at the same time we are running some side-line experiments and analyzing the juice of cane that has been fertilized in different ways and the juice of cane that has been raised in virgin soils as compared with adjacent soils that have been worked for a different number years. On this we have no data to offer. We have some fields, but we feel that we are not justified at all in discussing those fields as yet, and that we need still to cover many more fields, and then we will be able to make a general discussion of the results.

Corroborating the statement of Dr. Schreiner in regard to the potato disease, that it was due to lack of potash in the soil, we were confronted with a similar case in our tobacco plants in Cayey, Porto Rico. Our tobacco plants in that locality were doing very badly. Of course, whenever a plant shows an abnormality the first thing, the plant is diseased, so it was reported as a disease. We sent down our pathologist, and strange enough he did not find anything in the line of disease. Then we sent down our entomologist, and he also reported that although there were some insects in the plantation, yet he could not say that these insects ought to be made responsible for the amount of damage that he had observed. Then we sent down our chemist. The chemist went over the fields, took samples of the diseased plants, took samples of soils from the healthy fields and from the diseased fields, and those samples were submitted then to chemical tests. We had to give the planters an answer quickly, because those people want you to answer them in a very limited time The analyses from the healthy plants and those of the diseased plants, and the analyses from the healthy land and from the diseased land and these did not justify us in a general conclusion even though we were being rushed for an answer.

Now, Mr. Menendez raised the point here whether the nitrogen fertilization is affecting the purity of the juice of the sugar cane. We are not prepared to answer that, but we are on our way. We have established an experiment and we mean to start some more in our fields and experiment station. We have planted, I think, 84 lots. We have fertilized those lots with the different fertilizing ingredients and with different combinations. We have treated each lot five times, and each one of the lots is subdivided in egiht subdivisions. Now, we started just when I left Porto Rico to cut down the cane; we cut each one of these subdivisions in succeeding months, starting at the one of ten months; we cut it down at eighteen months. We feel that by cutting at a given age of the cane you do not arrive at a knowledge of the effect of the fertilizer on the juice of the cane. The weather condition may affect it in such a way that it is only by watching the effect of those fertilizers on the cane in succeeding months for a number of months that you may gain some idea as to the effect of those fertilizers on the juices. I want to say that we are analysing them for the sucrose and purity and we are also making ash analyses of those juices. In this way we hope to gather sufficient data to determine what is the effect of each one of these, in accordance with the nature of the combinations, on the juice of the plant.

Mr. Moir: In Hawaii we have been carrying fertilizer experiments and investigations, similar to those you have just heard about, for the last thirty years. Our results have been published from time to time. We practically know what the plant requires in many of our cane fields, but during the last five or six years we have begun correlating soil analyses with these experimental results. We have arrived at certain figures for the citrate soluble and the total by fusion, below which a response to phosphoric acid or potash has been obtained and above which no consistent response has been obtained. We find that a certain percentage of potash in the citrate soluble

along with a certain figure for total by fusion will mean definite response to potash, if potash is applied in those fields; and the same for phosphoric acid. A few exceptions to these figures have to be made for particular situations, such as alluvial deposited soils or decomposed coral rock, or for areas with excessive rainfall.

Along with these soil analyses we have been running analyses for crusher juice at the mill for phosphoric acid and potash, and at our last conference of Sugar Technologists in the Hawaiian Islands several papers were presented showing the correlation of this potash and phosphoric acid content of the crusher juice with the potash and phosphoric acid content of the soil in which the cane grew. We then tried to apply more phosphoric acid to those fields that were low in phosphoric acid, to see whether we coul recover it in the juice. We have not been successful in recovering any more phosphoric acid in the juice from the cane in those heavily fertilized areas, even where we applied phosphoric acid as high as twenty-five tons P2O5 per acre. Such an application burned the cane a little bit but in a week or so it recovered and at harvesting, 18 months later, we got no more phosphoric acid in the cane than in the adjoining plot where there was no phosphoric acid applied. But in potash the correlation is very decided. An increase of potash in the crusher juices is found as increased amounts of potash are applied to the soil. We feel that these crusher juice analyses are far more reliable for the potash than they are for the phosphoric acid. Last year we tried analyzing the bagasse along with the crusher juice, and getting the total amount of potash and phosphoric acid that is removed from an acre of land by the crop of cane that we have harvested. We have found on many plantations that they are taking out much more food than they are applying in fertilizers. How long can this unbalanced condition be maintained without a decrease in yield? We find that certain varieties take a good deal more out of the soil than others.

After securing these analyses, both of the juice and of the soil, we have been repeating many of our experiments, using very much larger amounts of nitrogen, phosphoric acid, and potash. We run our nitrogen per acre up to 300 pounds, phosphoric acid to 500 pounds, and potash to 500 pounds. Much to our surprise, plots which gave no response from 100 to 150 pounds of K_2O, gave us and increase of 1½ tons of sugar an acre for a 500 pound application. Plots where 100 or 150 of K_2O had been applied had even given a decrease of yield; when increased the amount of potash we got an increase in sugar yield and in juice quality. We find that in many of these soils that are deficient in potash, not only do we get this increase in tonnage of sugar, but we get a much better quality of juice through increase of purity and brix.

We have in many of our volcanic decomposed soils large areas where we have a great deal of soluble aluminum and iron. Canes grown on this areas are stunted and often killed out entirely. We have shown that deposits of soluble aluminum and iron are made at the nodes of the cane stalks. These deposits are similar to those found by Hoeffer in corn at Indiana. They, in time, prevent the passage of foods through the plant and a diseased looking condition arises. Phosphoric acid and lime will correct the soil condition in this case after a number of years. Increased tonnage of cane will result from increased application of phosphoric acid but if your condition is already serious in the plant, the only remedy we find is to apply potash. It acts just like a laxative; it cleans out the deposit of aluminum and iron and the cane will go on and grow normally in the course of a month from the application. This condition exists in many of our dry and unirrigated soils. In our

unirrigated lands, where we have a heavy rainfall, we are troubled more with soluble iron, and for this, potash is the greatest corrective we have. In many places we use as much as 250 pounds of K_2O over the entire plantation. In most of our alluvial deposited soils, soils that have been under water and have been drained out by large drainage canals, we get a very distinct response to potash and in nearly every one of these soils they use at least 200 pounds of K_2O per acre.

We have certain soils that are deficient in certain elements and which give us a diseased condition which we call Pahala Blight. Manganous sulphate has been applied to the leaves and has corrected the condition temporarily, but by applying sulphur to the soil the condition has been corrected slowly but more permanently. A good many cases of Chlorosis in cane, that is, yellowing of the leaves, have been corrected by dusting with the iron sulphate on the leaves, or a solution of iron sulphate sprayed on the leaves.

We are experimenting now with amounts of water in relation to amounts of different plant foods, and the soil moisture content resulting from such treatments.

We have found out that potash limits the spread of the eye-spot disease and makes the plant a good deal more resistant to its attack.

The biggest field for experimentation in fertilizer just at present is the time of application. We have come to the conclusion that we can make a bigger profit out of growing two crops in three years, instead of one crop in two years. Time of application, therefore, is a very important factor, and we find that the sooner fertilizer is applied the sooner you obtain cane growth, and the longer time you have for maturing and ripening the cane before harvesting. We have applied to some of these deficient soils 1,500 pounds of a mixture of 2-13½-12½, and in a month's time applied 1,000 pounds of 9-9-6 formula, and in six or eight weeks, 500 pounds of nitrate of soda, giving a total of 195 pounds of nitrogen, about 290 pounds of phosphoric acid and about 240 of potash, all within four and one-half to six months period from the time of planting or time of cutting in ratoons. The increased tonnage that resulted was remargable and far beyond any that we expected. Many of the plantations apply from 1 - 1¼ tons of fertilizer per acre per crop and secure profitable returns from such an expenditure. Most of this is applied within a 6-8 months period from starting.

Through our present investigations with fertilizers, water, and varieties we have been carried into a study of the root growth of the plant in relation to these plant foods and soil moisture. I feel that if a great deal more work were done along these lines we would be able to solve many of the problems of growth failure, and grow much larger crops than we now do. We are carrying out some detailed work on an analysis of the roots and stalks at different stages of growth with varying treatments of water and plant foods and soon ought to get a great deal of information from such work.

Mr. Agee: In our experimental work we have found considerable assistance in interpreting what is going on by the use of growth measurements. The point is that a cane stalk at this point (shown by diagram on blackboard) if you measure from the ground surface, or if you prefer, from a small place here, or if you prefer, in the case of a longer stalk, from some point which you establish on the stalk itself by a mark of some kind, and measure from this base point to the higest visible leaf joint. The cane leaf, as you know, where the leaf sheath joins the blade, has a distinct leaf triangle as it is sometimes called. If you measure to this point you can get a fair indication between this point, and your last measurement, of the growth

which has taken place recently. If you measure to the highest well formed point, you get the growth that took place several weeks earlier, because the active growth of the cane is taking place in this spindle which is enclosed from view. Now, we use this measurement not in comparing one variety with another so much as in studying what is taking place from week to week or from month to month. They are of particular interest in our irrigation work. Our season, as you know, extends eighteen months, sometimes more, and in studying the value of irrigation water at different periods of the year, we find these growth measurements of particular interest and value. They work in a way as an experimental basis and you will hear the pros and cons as to the value of growth measurments, as to whether you can confine yourself to linear growth, or whether you should also include circumference. The linear growth will give you a fair indication, and if you want more, you can get it very nicely by including circumference and by estimating the volume of cane produced. The question of the number of stalks to take these measurements on in a given field or a given row, the question of whether you can confine them to primary stalks or you take stalks representing both primary and secondary; all those are questions on which opinions differ a little bit; no one doubts that if you measure all the stalks you would get more accurate data, but you wil lget accurate enough data if you confine yourself to a sufficient number to give a fair indication of what is going on. You can apply that to the benefits of the fertilizing material and the benefits of the irrigation water. You can differentiate between the value of irrigation water in the hot months of July and August, as against the cooler months of February and March.

The Chairman: I woul like to ask Mr. Earle to tell us something about land preparation, and particularly in Cuba and his experience.

Mr. Earle: I feel that I have been assigned a rather difficult problem, to generalize on soil preparation. I feel like asking Mr. Chairman which field does he wish me to talk about to-day. It is very difficult to say much that will be generally applicable. In fact, whether we are to choose animal power, or tractors, or steam plows, is largely a local question also. There are a few points, however, that perhaps will lend themselves to general consideration. Since the advent of the big steam plow and the ability to make very big furrows, I think there is a little tendency in the sugar world to perhaps over-estimate the value of deep plowing. Here again we have absolutely a local question. There are soils where, if you can afford the expense, you may plow to three feet deep with benefit, and there are others where such plowing is manifestly a mistake. Again the season of the year has a good deal to do with how deep we should plow. Here in Cuba a great deal of the peparation of the land is made late in the Summer for Fall planting. Now, if we plow very deep after the last heavy rains, we are going to have great difficulty in restoring capillarity and get maximum growth during the dry season. For many of these reasons it has seemed to me for years that cane farmers, as a rule, were laying too much stress on depth of plowing, and not enough stress on proper seed bed preparation. I think that, personally, I am more interested in getting a good seed bed in the upper eight inches of the soil than I am on what is going on below, that it, speaking of a reasonably good agricultural soil, and that brings up the point that most of us neglect, what to my mind is the most important implement of all, and that is the harrow. We pay too much attention to the plow and not enough to the harrow. Again many of our Cuban lands are heavily set with grasses and this makes a serious complication in preparing the land, except during the rainy season.

If we go into one of these grassy fields and plow deeply, we simply bury the grass, and it is quite important in lands of this character that the grass be killed before any deep plowing is done. The first plowing on grass land should always be shallow and have repeated harrowings. After killing the grass you can go in and plow as deep as you care to go. Another very considerable point that will have to be taken into consideration is the nature of the soil, and secondly the method of planting that is to be followed on this land. That is a point which most of us here in Cuba are a little at fault. We learned cane agriculture on red land, and when the industry is spread to other districts we tried to use that same red land method on our black lands. It does not work. I think there about three principal methods of soil preparation, or I had better say of cane planting, that will be applicable to almost any soil condition. I call thell first one the Cuban method, where it applies to lands like our Cuban red lands, where there is no trouble, where the subsoil is so permeable that the rainfall finds its way downward, and we do not have to provide drainage ditches of any kind. Here minor preparation and deep planting furrows are sufficient, but when we go on to our Cuban black lands here we must apply entirely different methods. The most practical way in which to secure proper drainage, I wish to say that I do not care how many big main ditches you make to fields of that character, you are not going to get sufficient drainage until you get local drainage, some soils are so impervious that water does not go down or sidewise; we must get it off the surface, and to do this the water courses must be very close together. Therefore, the practical method of handling these soils is to plow it into narrow banks. They can be banks with room enough for two or three rows, according to the pleasure of the cultivator and the nature of the soil. I prefer a four-row bank. You can make it with plows, simply by back furrowing, as we say. With tractors it is more difficult, but it can be done very nicely, and then the water furrow between these banks must be cleaned with some implement in the nature of a Martin Ditcher, or a big double mold plow, and there you have sufficient furrow to carry off the surface water every few feet, and the cane can then be planted on these banks and cultivated with level cultivation. The other improved system of planting I would call the Hawaiian method of planting because it came from Hawaii and I became familiar with it on the south coast of Porto Rico, where irrigation is employed. Here in place of running the rows with the fall to secure drainage they run across the field, and the water is carried across these furrows. I think almost any soil condition can be met by one or the other of these methods of preparation, but as I said, the question is such a local one that it is very difficult to make any remarks that will apply generally.

Mr. Matz: In Santo Domingo we are increasing the production from ratoons very considerably by the use of subsoil plow or knifer. This implement drawn by Fowler tackles, has a trash cutter just ahead of the knife which cuts the blanket of trash and permits free passing of the implement.

Dr. Faris: I have been asked by the Committee to make a few remarks about the present trend of cane cultivation in Cuba. As some of you will remember, the beautiful cane in Java shown by the lantern slides of Dr. Jeswiet, was grown by a Cuban system of cultivation once in use in a number of plantations in Cuba. I refer to the system of Dr. Reynoso, described in his publications of some sixty-five years ago and again made available through the generosity of Col. Jose Miguel Tarafa, one of the foremost of Cubn planters, who has had reprinted the studies of Reynoso.

The Reynoso system was applicable to the condition of slave labor then existing in Cuba, but with the abolition of slavery and the incrase in the cost of labor new adjustments became necessary and our present "colono" system grew up. Various cultivation systems were developed, but the one most generally used in ratoons in western Cuba and which seems well adapted, both from the standpoint of cost and sustaining yields, is the transfer of trash to alternate middles and the cultivation of the exposed middles. The tendency at the present time is to find methods of carrying out these operations mechanically at low unit cost. On every hand you will see demonstrations of machinery for land preparation, planting of the cane, covering it, cultivation, transfer of trash and ratoon cultivation. With a deficient labor supply and vast expanses of land suitable for cane, I believe we may look forward to a development in our cane cultivation comparable to what has taken place in the growing and harvesting of wheat in the grain belt of the United States. That is, we will probably be satisfied with a lower per acre yield than countries favored with an abundant supply of cheap labor or with protective tariffs, but we will strive, thru the use of machinery, to reach a higher per man yield. In western Cuba we have native labor of sufficient intelligence to handle such implements and there is a keen interest on every hand to develop labor saving devices which will reduce the unit cost of production. If a cane harvester should prove successful and sufficiently cheap in operation, I can easily believe that our selection of varieties and cultivation methods might be adjusted to its use. The popular description of Cuban cane culture is that of timber planting but I should remind you that the industry of western Cuba is considerably over a century old and that here in Pinar del Río, Havana, Matanzas and Santa Clara Provinces, the stumps in the fields have long since ceased to be a difficulty in cultivation. As you think of our cultivation problems, please do not visualize all of our fields as full of stumps and logs. They are not all that way and we see the day fast approaching when very few of them will have those impediments to the use of implements.

Do not misunderstand me. The present tendency in Cuba cane culture is to continue proven operations but to develop methods of carrying them out which will be more economical both with money and labor.

THE CULTIVATION OF RATOONS IN UN-IRRIGATED CANE FIELDS IN CUBA

By R. Menendez Ramos

Trash Lining and Implement Cultivation of the Clean Middles.
(This paper, with illustrations was published in The Reference Book of the Sugar Industry of the World, July 1927)

Mr. Clarke: Trash lining and inter-row cultivation have formed an essential part of cane cultivation in Fiji for the past 30-40 years, but within the last four or five years modifications have been necessary on account of labor shortage.

Dr. Storey: Told the Chairman later that trash lining is a usual practice in South Africa and has been for many years past.

VARIETIES CULTIVATED IN FORMOSA

By Dr. Migaku Ishida.

In our last campaign in Formosa we produced 550,000 tons of sugar, about 85% of the output of the Japanese Empire, 100,000 tons being produced in Japan

proper. We consume about 800,000 tons so that there is still a shortage of about 150,000 tons which we buy from other countries chiefly Java and Cuba.

In 25 years we have increased our yield 16 times, our goal being 28 tons per acre but at present we have reached only to 19 tons, although some of our companies have reached as much as 28 tons.

The sugar industry in its modern conception in Formosa has developed since 1901, in which year the first modern factory was built in Kyoshito in the southern part of the Island. At that time the Formosa Government planned the establishment of a large scale sugar industry.

Before 1901 the cane varieties in Formosa were some of the so-called Japanese or Chinese canes. The rose Bamboo and Lahaina canes were introduced from Hawaii by the government. The Rose Bamboo has grown very well over the Island and the success of this variety accelerated the establishment of a great many new sugar factories.

Cultivation of this variety was continued until 1910, but this cane was attacked by diseases such as red-rot and by insect pests like the stalk borer. In 1912 the cultivation of sugar cane in Formosa was damaged greatly by a Typhoon and the production was reduced more than 40% as compared with the previous year.

Owing to the possibility of such wind damage we tried to propagate wind-resisting canes and some of the Java canes have given excellent results to the present time in Formosa. Of course, some of these varieties are very hardly from several points of view.

The following table shows the varieties cultivated at present in Formosa and the area devoted to each with the percentage of area covered by the more important ones:

Cane Varieties Cultivated in Formosa

1926B-1927 Crop

Varieties	*Area*	*Percentage of Area*
POJ 161	79.284 acres	33.5
POJ 105	37.990	16.1
POJ 2714	29.023	12.2
POJ 36	24.158	10.2
POJ 2725	17.363	7.3
F. 19	14.299	6.0
POJ 36 (M)	9.297	3.9
Yontanzan	4.844	2.0
D. 117	4.24	1.8
POJ 234	3.786	1.6
F. 4	2.610	0.95
POJ 2727	2.246	
ROSE BAMBOO	1.438	
POJ 143	.801	
F.	.422	
Tek-chah	.189	
Other	4.450	1.9
Total	236.536	

Mr. Clarke: The question of the form of Potash that should be used has been brought up. Has anyone any information on this subject?

Mr. Moir: Hawaii.—On irrigated soils where we use saline water we prefer the sulphate of potash as the muriate has a depressing effect. On unirrigated lands we use the cheapest form.

Mr. Clarke: Any information on other elements necessary for plant growth?

Mr. Moir: In areas suffering from chlorosis we took some rusty nails and stuck them in the seed pieces and found that the plants came up normal instead of chlorotic. The amount of iron we put there, although small, seemed to help the cane.

Mr. Clarke: Information in regard to dipping seed.

Mr. Moir: Treating the seed pieces with Bordeaux mixture we found to be detrimental, as it cuts down germination. We then made up a paste of Bordeaux mixture and dipped the ends of the seeds in this with a similar loss in germination.

Mr. Lopez: In porto Rico it was found that an increase of 15% per acre was obtained from seed that was dipped in lime water and magnesium sulphate. It germinated very rapidly and gave a larger yield.

Dr. Brandess For stimulation of germination we have tried forms of sodium, ammonia and calcium, using about 2% liquid solution and treating the seed pieces with this solution for about two hurs. This caused a marked stimulation of growth and germination. This is just one of a number of tests being carried on at Washington. I noticed in cane shipped from Java that was so treated that it came back in germination about 70%. This was suggested by the work of Dr. Bennett upon "Stimulating the germination of potatoes by these solutions".

Mr. Lopez: In the matter of dipping seed cane in Porto Rico, we took about five tons of lime mixture and dipped the cane in that solution. It caused much better germination and quite early growth. I do not know if it has been done in large scale or not. Personally I do not think that dipping seed cane would be practical in a large plantation.

I know it has been done in Porto Rico with success under experimental conditions. I do not know of any plantation that has done this as a regular procedure. Dipping seed cane to prevent disease was recommended and tried but after a time the people got tired of dipping the seed and forgot about it .

Mr. Taggart: Conditions in Lousiana are different from those of the rest of the countries growing cane. We have a period in which cane is not growing, which are the winter months of December, January and February. Our cane is not growing during these months and we found that naturally trash has to be practically decomposed before plowing it under. We found if we buried this trash that it will not decompose but will remain in the soil and have an injurious effect during the growing season. Therefore, we take advantage of the dormant period and use just sufficient soil to mix with the trash, keeping it in a mulch close to the surface and ground and during these moist months decomposition will take place very readily. The trash does not interfere at all with the cultivation. Some of our chemists are working on the relation of nitrogen to trash handling. The work is not by any means complete but we have found so far that if the trash is buried quickly the nitrogen is at first locked up to be released later, hence by using this trash to lock up the nitrogen during the dormant period we believe we are conserving the nitrogen for a time when the cane will take advantage of the increased fertility by active growth.

Sr. Bonazzi: We have done some very interesting experiments at San Manuel, Oriente, Cuba, along these lines. One of our most difficult problems is the conservation of soil moisture. I say difficult because during the dry season moisture in the open exposed areas of this soil is so low that decomposition of plowed under trash becomes very slow and difficult. In addition to that we find under the local conditions of rather high temperature that the trash seems to take up nitrates at first increasing nitrates slowly after a period of time. We made studies on three types of plots: one, a plot where no trash had been allowed to accumulate; (2) a plot where the trash had accumulated in the surface, and (3) where the trash had been incorporated into the soil. During the planting season we have an increase in rainfall from April to July, and dry weather from July to October. If the incorporation of trash is done at one of the periods of heavy rain tre production of nitrate is very rapid, but if done in the dry season of the year, decomposition is very slow.

I have tried experiments in plant cane and ratoon cane and have found that when the trash has been incorporated at the dry time of the year, the plants were stunted in growth. You could easily notice the difference in the plants between areas where the trash was incorporated and those where the trash accumulated on the surface. In order to help speed up this slow incorporation of organic matter, the trash must be plowed in during the rainy season. I believe we should consider the incorporation of the trash in the soil both from the standpoint of improving the physical condition and for enrichment of the soil by the addition of organic matter. The possibility of utilizing this trash by means of plowing it under, depends a great deal on the atmospheric conditions. During the rainly weather and in areas where a thin layer of trash was plowed under I found it practically decomposed at the end end of fifty days. One of the problems which requires attention in this matter of incorporation of trash, is a mechanical means of quickly and efficiently burying it. We have used an ordinary mouldboard plow with runner to hold the trash on each side of a rolling coulter until it is cut. From our work upon the trash, I am not trying to make any specific conclusions as it is all in the experimental stage. At present incorporation of the trash seems to be somewhat dependent upon the time at which it may be of most benefit to the soil.

Mr. Maier: In Florida the practice of leaving the trash on the peat soil and applying the fertilizer no top of the trash, is giving the best results.

Mr. Agee: In Hawaii we have fields very old, 20, 30, 40 and even 60 years which have been continuously cropped in cane with very little of the trash put back, if any at all, and we are today in almost all of our districts making our record yields. We do that by using fertilizer. We could not grow cane at all in Hawaii if we did not use fertilizers. One of the most interesting effects of not burning the trash is the influence on the parasites of insect pests. I think the problem or incorporation of organic matter in the soil varies so much that we cannot be too general in our statements.

Mr. Ageton: Has any one found the correlation between the aplication of potash as a fertilizer and cane juice, purity, sucrose, etc. On areas which have been burnt repeteadly over a period of 20 years it stands out quite markedly that the condition of the soil has been modified so much that it is known locally as "tierra secante" or dry earth.

Mr. Agee: In Hawaii we have lands which in general are more firable than those of Cuba and we do not have the type of Matanzas red soil that you have here in Cuba, our lands being mostly volvanic. Also the moisture condition varies great-

ly with us as the rainfall varies from 15 to 150 inches per year and we apply irrigation water to the drier districts.

Mr. Matz: I may say in the matter of utilization of cane trash in Barbados that they call trash what we would term pen manure. After the cane is harvested the trash is carried to corrals in the neigrborhood of the mill and in these the livestock are kept for several months. The decomposed trash mixed with the manure sometimes reaches a depth of three or four feet in these pens. The land for planting cane is prepared by digging holes 4½ feet apart for the cane seed. Between two of these an extra hole is dug in which they put this decomposed trash, pen manure, etc., and then cover up. The cost of taking the manure to the field, putting it in the holes, making the holes, and covering is from $5 to $6 per acre. There is no doubt about the beneficial effects of the application of this decomposed trash as they are getting very good results from it. They use only about 200 pounds of sulphate of ammonia per acre for the maintaining of the fertility of their lands, which are very shallow and poor. They would not change this system under any conditions as they have been getting good crops from the same land years in succession and the land has not given out. With from 35 to 40 inches of rain per year, they are securing crops of 30 tons of cane to the acre. The rate of pay in British Guiana is a shilling per day, 22 cents. This makes about 2.10 per acre to make the holes (about 2,000 holes per acre, 2½ feet apart). To bring the manure from the piles and carry it to the holes about $2.10 per acre. All about $5.00 per acre.

Dr. Miyake: In Formosa we use the Reynoso system of cultivation as they do in Java, planting the cane in deep ditches and filling these as the cane grows. We remove the leaves from the cane, piling them in the middles. In certain varieties of cane the trash is hard to cut down and for that reason many of the factories burn the trash before harvesting the cane in the dry season.

Mr. Matz: The question of the preparation of the soil has been solved in Porto Rico and Santo Domingo. It is a question of the land being kept loose and sufficiently moist to enable the roots to take up the food elements needed for their growth. We employ the knifer with great success. This implement is operated with one of the heaviest Fowler steam sets. We go down to depths of 24 inches, ordinarily the knifer is first past to destroy and bury the trash and then we cross knife and harrow, which leaves us a very good seed beed. This deep preparation has helped us in the control of root disease. It is remarkable that through subsoiling, places that were hot beds of root diseases are practically free of them after several years of subsoiling. Old ratoons have been improved wonderfully by the use of the ratoon knifer mentioned above.

STIFF CLAY IN RELATION TO CANE YIELDS

Submitted by Maurice Bird (British Guiana)

ABSTRACT

At the end of 1924 after an exceptionally fine growing season, considerable areas of cane began to wither at the top, growth seemed to cease and death ultimately ensued.

The government mycologist did not consider this due to disease. Cane roots, stalks and leaves were finely chopped up, dried, and burnt to ash. Lime and magnesia were then determined. Soil samples were also analyzed.

Analysis of the soil upon which the cane referred to above was grown:

Analysis of the Soil Upon Which the Above Referred to Cane was Grown

ESTATE FIELD	DESCRIPTION	VOLATILE MATTER	*Ingredients soluble in a 1% Solution of Citric Acid Per cent. - soil* LIME	MAGNESIA	RATIO OF LIME TO MAGNESIA	POTASH	SODA PHOS.	ACID
"Withered" Cane								
P. M. Tain Windward 26	Gray Clay	13.64	.077	.029	1.37	.017	.113	.003
R. H. B. D. 15	Gray Clay	16.47	.043	.032	1.74	.029	.024	.003
"Good" Cane								
R. H. Canefields 33	Dark Gray Clay	17.02	.035	.019	1.54	.019	.005	.005
P. M. Ank. O. G. 15	Dark Gray Clay	14.52	.082	.014	1.17	.018	.055	.005

N. B. Much apparently good cane died later.

P_2O_5 in soils was low but not necessarily serious. Soil poverty was not the cause of the dying. Lime magnesia ratio is not satisfactory. The probable explanation of the trouble is the toxic effect of excess magnesia over lime.

The soil is a very impervious, very stiff clay and the movement of soil water in it is very slow. The lime in it is very low.

Very rapid growth of cane means extended foliage and and increased demand for lime; the impermeable nature of the soil makes this difficult to get, and so we get the production of the toxic ratio of magnesia to lime.

After the death of the cane, the ratio is slowly restored, and the new crop does not suffer.

There have been three such epidemics recorded in British Guiana and each followed by an exceptionally good growing year.

Using H Cl as the solvent the soil shows more magnesia than lime, using 1% citric acid the soil shows more lime than magnesia. Soil roots are supposed to resemble in solvent action in soil the action of 1% citric acid solution. Therefore, the roots will tend to take up the lime more rapidly.

Shortage of organic matter affects soil conditions as regards permeability and is, therefore, regarded as the determining factor in controlling this trouble. The author quotes the late Sir John Harrison as endorsing this view.

Analysis of the Ash of the Juice from "dead" and "dying" Cane Respectively

	"Dead"	"Dying"
Silica % Ash	10.83	7.69
Lime % Ash	2.74	2.13
Magnesia % Ash	7.63	4.88
Potash % Ash.	22.18	20.29
Soda % Ash	1.14	1.26
Phosphoric Acid % Ash	2.81	1.92
Sulphuric Acid (S.03) % Ash.	13.39	14.05

Analyses of the ash of portions of withered and good cane are shown on the following table.

Lime and Magnesia in Ash of "Withered" and "Good" Cane at "P. M." and "R. H." Estates.

	Estate	*Roots*	*Stalks*	*Leaves*	*Date Harvested*
"Withered" Cane					
Lime % Ash	P. M.	1.60	3.62	3.13	11.7.25
	R. H.	.48	1.22	2.05	28.3.25
Magnesia % Ash	P. M.	2.12	7.70	2.66	11.7.25
	R. H.	1.26	5.44	2.12	28.3.25
Ratio Lime to Magnesia	P. M.	1:1.3	1:2.1	1: .84	
	R. H.	1:2.6	1:4.4	1:1.0	
* *"Good" Cane*					
Lime % Ash	P. M.	1.10	3.13	2.01	13.7.25
	R. H.	.52	1.88	2.52	2.5.25
Magnesia % Ash	P. M.	.97	7.54	2.63	13.7.25
	R. H.	.81	6.55	2.61	2.5.25
Ratio Lime to Magnesia	P. M.	1: .88	1:2.4	1:1.3	
	R. H.	1:1.5	1:3.4	1:1.0	

* Although this cane appeared healthy at the time of sempling much of it died subsequently.

SECTION VI.

PROCEEDINGS OF HAVANA CONFERENCE

FACTORY OPERATION AND CHEMICAL CONTROL

W. R. McAllep, *Chairman.* G. M. M. Phillips, *Secretary.*

Part 1. MILLING.

Cane Knives.
Shredders.
Crushers.
Grooving.
Aplication of Pressure to Mills.
Intermediate Carriers.
Imbibition vs. Maceration.
Juice Strainers and Mill Sanitation.
The Milling of Badila Cane.

SECTION VI.

Part. 1. MILLING.

Tuesday, March 15th, 1927.

CANE KNIVES

D. M. Semple (Mirrlees-Watson Co.; Great Britain (Chairman).

Cane Knives are being used in Hawaii more than anywhere else, so I would like to call on Mr. McAllep to tell us something of what they have been doing there. I believe that the first cane-knives to be used at high speed and absorbing high power were used in Hawaii.

W. R. *McAllep* (*Hawaii*).

Revolving knives were coming into general use when I became associated with the industry in Hawaii about thirteen years ago.

The benefits obtained from knives can be ascribed to two causes; first, they give an even and steady feed of cane to the mills, second, they cut up the cane into chips so that it is able to absorb maceration at an earlier point in the milling-train. The first point is especially important on what we call "non-fluming" plantations, that is plantations that receive their cane in cars in the manner usual in other parts of the world.

On "fluming" plantations, a system of flumes brings the cane to the mill and delivers it direct to the carrier, by a steam of water. With this system it is easier to load the carrier evenly because the delivery of cane is under good control. Hence on these plantations the only value of the knives is to prepare the cane for maceration. In a few cases a set of knives with a few blades is installed at the head of the carrier. On fluming plantations tests of the fluming-water have invariably indicated losses of sugar when the cane has been finely divided by close-set knives. When the carrier goes back under the flume any juice expressed by the knives is washed off and lost. Even on a non-fluming plantation, when a set of a great number of blades is used it is question of great importance whether this juice is expressed and gets on

the carrier, is carried into the mill and recovered of whether it stays on the carrier and ferments. If a very fine disintegration of the cane is required my preference is for a shredder rather than knives. though, I consider evening-up the feed with knives very advantageous.

The use of knives increased rapidly, particularly on non-fluming plantations. Two sets were frequently used. The first set was placed near the bottom of the carrier to level th cane. The second set was place at or near the head of the carrier, the tips of the knives running as close to the carrier as practicable, a minimum of about 1". However, in recent years, both on account of the power required and the amount of juice squeezed out by the knives there has been a general tendency towards less heavy preparation of the cane by knives.

Setting the knives close and using such a great number of blades caused a considerable loss of cane in chips falling through the carrier. This led to discarding the wooden slat conveyors and adopting conveyors with overlapping steel slats which prevent chips falling through.

Note, by Mr. Semple:

The number of blades was such that they were pitched about 1" apart across the carrier; they ran at 450 or 500 r.p.m.

Nate by Secretary: Recent sets of knives in Cuba have only half as many blades as this, the pitch being 2".

Geo. W. Connon: (*Honolulu Iron Works Co., Cuba*).

Revolving cane knives were first introduced here in Cuba six or seven years ago by Mr. Elmo Miller, who has charge of the factories controlled by The Royal Bank of Canada. He installed a set al Central Baguanos and another set at Central Rio Cauto. About five years ago the Honolulu Iron Works Co.. installed three or four sets; at the present time there are probably 18 or 20 sets of knives in Cuba. Cane knives increase the mill capacity anywhere from 12% to 18%; they also increase the extraction by 0.5% to 1%, or in some cases even more.

They are a decided benefit and I belive that in the near future they will be in quite common use here in Cuba.

Manuel A. del Valle, (*Central Constancia, Porto Rico*).

Will you kindly tell us the horsepower consumed?

G. W. Macpherson Phillips, (*Honolulu Iron Works Co., Cuba*).

On the knives used in Cuba, set close to the carrier it averages about 85 HP for 85 short tons of cane per hour, and reaches 180 HP for our very large grinding rates of 230 tons per hour (435,000 arrobas per day). These figures are for knives in average condition at the end of a week's run; when freshly sharpened power is much less.

Mr. N. Bennet, (*Sugar Experiment Station, Australia*).

Can anybody here tell me if you get the same benefit in extraction from a set of knives using 180 HP as you would from a mill or another shredder using equivalent power?

Mr. Cannon:

The benefit is about the same as a crusher and, of course, considerably less than a three-roll mill.

Lee G. Camp (*Consulting Engineer, Havana*).

A study of the work done by the several factories equipped with Cane Knives as shown by the semimonthly reports in determining capacity of the Cuba Sugar Club, suggests that Cane Knives may be treated as equivalent to one additional roll

in the mill train, or in other words they are equivalent to 50% of a crusher. Further analysis may develop the fact that they are entitled to a higher rating, but as yet we have no basis upon which sush higher rating may be assumed.

Miguel de Arango, (Central Andorra, Cuba).

At Central Andorra we were grinding about 150,000 arrobas now, since we installed cane knives, we grind 175,000 arrobas per day, (92.4 short tons per hour). We set the knives ½ above the 4" angle-irons attached to the slats, that is, 4½" from the slats. On the average, less than 100 HP is used for a grinding of 120,000 arrobas per 24 hours (equivalent to 63.4 short tons per hour). Sometimes a peak-load swings up to 200 HP. The mills have been running much easier and we now drive them slower because of the increased capacity.

Note by Secretary: An arroba, as used in Cuba, is 25.36 pounds avoirdupois.

Mr. McAllep.

We obtain better capacity with knives. I consider it preferable to set their slightly beyond the head of the carrier and with the tips of the blades about in ling with the upper surface of the carrier-slats. Knives greatly improve the feed to the rolls or the shredder. They improve capacity in two ways: by reducing the number of chokes, and by keeping the mill full from one side to the other.

Mr. Semple:

In Hawaii, of the 40 factories reported in the Annual Synopsis of Mills, 31 are operating with knives.

Mr. Connon.

At Central Cuba, with a double crusher and 18 rolls, they grind about 400,000 arrobas (211 short tons per hour) and obtain 96% extraction, using 2700 indicated HP on the mills. At Vertientes, with one set of knives and single crusher and 21 rolls, they grind up to 470,000 @ (248 short tons per hour).

Cane knives give a better and steadier feed to a mill. Without knives, the crusher sometimes tends to choke, thus giving a light feed to the following mill; cane-knives obviate this, and thus the mill-rolls are kept full all the time. This is one of the reasons why knives enable a higher capacity and a better extraction. But the main reason for the improved extraction is that the bagasse in the earlier mills of the tandem is more finely-divided and therefore better able to absorb maceration.

Note by Secretary: Central Cuba, when grinding 350,000 arrobas (185 short tons per hour), used 2520 Indicated Horsepower.

Mr. Del Valle:

Knives were installed for the first time in Porto Rico this year in three factories; these factories have increased their capacity by 15% to 20%. As to horsepower, we find that the knives consume much less power at the beginning of the week than at the end of the week. For instance, at Central Loiza, grinding 150,000 arrobas, (79 short tons per hour), the knives require 20 HP the first day and 40 HP at the end of the week because of the dullness of the knives.

Mr. Connon.

At Central Vertientes, grinding usually 420,000 arrobas (222 tons per hour) and some days as much as 470,000 arrobas (248 tons per hour), I believe they sharpen the knives every ten day or two weeks. Other places that grind about 2000 tons a day, I believe only sharpen them three or four times during the season.

R. Clayton, (Colonial Sugar Rfining Co., Australia).

Cane knives have been in use for at least twenty years at the Colonial Sugar Refining Co. mills. Originally they consisted of a single set of slow-running and widelyspaced knives, but during the last six or seven years the practice has been to put in two sets. One set is placed half-way up the carrier, and has blades set about 6″ apart revolving at a comparatively low speed and operating on the upper layer of cane; the other is placed at the carrier head and runs at bout 450 RPM with knives 2″ apart having their points set to within 1″ of the carrier boards.

In some installations the knives are held between light cast steel discs mounted on an octagonal shaft, the discs and knives being secured between a collar and masternut on the shaft. This arrangement makes the substitution of a set of sharp knives for blunt ones a much quicker operation than where each knife is bolted on separately.

Mr. Connon:

The most successful type of construction in Cuba has been the "Ramsay" swing-blade knife. This design was developed in Hawaii to avoid the constant breakage of blades that had been experienced with all types then known. The breakage was caused partly by striking accidental pieces of iron among the cane, but mostly by fatigue of the metal near the root of the blade. Rarely is a stick of cane presented squarely to the knife; the blade therefor usually strikes a glancing blow and is subjected to a sidewise strain. It is well known that a few million repetitions of heavy strain, (although well below the actual breaking-point), will eventually break a piece of metal. Each knifeblade strikes 500 blows per minute, or 720,000 per day. Thus, for instance, if only every fourth stroke strains the metal to the fatigue point, it will only take sixteen working days to reach 3,000,000 applications of this strees, and breakage is then probable.

The construction of the "Ramsay" knife is as follows: A series of cast-steel hubs are strung on the shaft. Each hub carries two hinge-pins, one on each side. On each pin is suspended a knife blade, by means of a loop rivetted to the blade. The pin is in the same plane as the blade, and its length is at right angles to the length of the blade; each blade is therefore free to swing sidewise, (i. e., with a movement parallel to the length of the shaft), but not in the direction of rotation of the shaft. A glancing blow on a stick of cane, or any oscillation or lateral play of the shaft, therefore simply causes the blade to swing a trifle on the hinge-pin, and puts no strain on the metal of the blade. Similarly this action absorbs the effect of a blow on an accidental piece of iron (unless the surface of the iron be presented quite square to the path of the blade) which might be sufficiently to break a rigid blade immediately.

Mr. Arango:

This year we are trying out a new type of blade which we find does not require sharpening. When it gets dull on one side, it is simply taken out and reversed, and we find that the action of the cane sharpens back edge so that it can again be used as a cutting edge. Mr. Connon can give a description of these knives.

Mr. Connon:

This type of knife is made with the idea of gettin away from the sharpening which is necessary on other types. These blades, are of the "Ramsay" swing type, and therefore can be very easily taken out and reversed. The end of the blade is a flat ellipse in contour, the front edge being identical with the back edge. The blade is reversed edge for edge once a week, so that each edge is used one week for cut-

ting and the next week trailing (i. e., at the back edge of the blade). It appears that the cane sliding off the back edge sharpens it so that in a week's time it is ready to be used again as a cutting edge by reversing the blade once more.

SHREDDERS

Mr. Semple (Chairman):

I believe that the first real cane-shredder is still used in Australia; I think this was the Newell Shredder. I would request Mr. Clayton to say something on this.

Mr. Clayton:

The shredder in use at our mills is a modification of the old shredder called, I believe the National. The shredder cutters are of chilled cast iron and subject to very rigid inspection during manufacture. Under normal conditions they have a life of 80,000 long tons, but this figure would vary between wide limits depending on the variety of cane, the amount of foreign matter brought in with the cane, the crushing rate, etc. The relative speeds of the two shafts is 4½ to 1, the faster one running at 670 RPM.

I have not exact figures for lost time due to shredder trouble, but it certainly does not exceed ½% of the available factory time.

Mr. Camp:

At Central San Antonio in Santa Clara Province, where I was employed as Superintendent Engineer in 1911, they had a 54" National shredder operating in conjunction with three 5 ft. mills, the first of which was provided with a Maxwell steel-shell crusher-roll.

We ground at a maximum rate of 84,000 arrobas per day (44.3 short tons per hour), and I believe that this about represents the maximum capacity, under Cuban conditions of operation, for a National shredder of that size.

The shredder did excellent work when operating; however, due to the defective design many interruptions were experienced. For the information of these not familiar with the type of shredder, it may be described as two cylinders supported by light inclined housings similar to the ordinary crusher housing; the journals of the lower cylinder are held rigidly in place, while those of the upper cylinder are allowed to travel in guides and held in place by compression springs.

Mounted on the surface of the cylinders are a series of "V"-shaped rings of about 6" face and provided with serrated surfaces, the rings being so placed on the cylinders that the acute angle of these serrations formed cutting or shearing edges.

The machine operated at comparatively high speedfi the top roll being driven approximately 175 revolutions a minute, the lowar at twice that speed. The serrated edges of the lower roll seized the cane and carried it across the surface of the slower revolving upper roll, thereby splitting or shredding the cane in a very satisfactory manner without the extraction of juice.

The rolls were driven by Link leather belts, the one on the lower roll being crossed. As stated, the upper roll was held down by springs, and it was our experience that whenever a large bundle of cane was fed into the shredder the top roll jumped up and down in the housing to such a degree that the drive belt very often decided to go elsewhere.

We also experienced considerable difficulty in maintaining satisfactory lubrication.

During the first season of my experience with this shredder I caused a record to be kept of all interruptions or stoppages, which usually were of from ½ minute to 10 minutes duration due particularly to failing belts. At the end of the crop we

found that these stoppages represented a total loss of time slightly in excess of 2 days. Obviously, such operation was decidedly unsatisfactory from a practical stand point.

The next season we endeavored to overcome these difficulties by the use of an especially heavy link leather belt 1" thick, the belt driving the upper roll being put on so loosely that the two sides almost touched. Much heavier springs were also installed to reduce the continuous jumping of the upper roll. This was found to give satisfactory results, and the total time lost amounted to only a very few days throughout the crop.

We solved our lubrication trouble by the use of "Gredag" applied by very heavy compression cups.

It was during this season that we obtained a grinding rate of 84,000 arrobas (44.3 short tons per hour) and a sucrose extraction of 92%, although only one of the cane mills was equipped with hydraulics.

While I doubt very seriously that I would consider the installation of a National shredder in any plant under my supervision, I may say that my experience with this machine predisposed me to a favorable consideration of the principle of cane shredders. I have not had any experience with the Searby shredder, but have endeavored several times to effect an installation of such here in Cuba. I am throughly convinced that the principle of cane shredding is correct, and any problems that may exist are those of a mechanical nature.

Going back to the construction of the Newell shredder, formerly the rings were made of cast iron with a chilled surface, but in more recent years I understand that the manufacturer has substituted manganese steel. This should make a very marked improvement in operation, as with the old cast iron rings considerable difficulty was experienced from breakages due to iron and other material entering with the cane. Of course, that is a difficulty which almost always exists in any machine operating at high speed, and no doubt has caused some difficulty in other types of shredders as well.

It may be of interest to state that the milling plant and shredder are still in operation at San Antonio. This plant is really a museum of mill equipment, the second milling unit being driven by an L. P. Morris walking-beam engine bearing construction date of 1847, while the youngest mill of the set was built by Moore and Cook in 1863.

Mr. McAllep:

A number of shredders of this type were in operation in the Hawaiian Islands a number of years ago, but they have gradually been replaced for one reason or another. There is one National Shredder still in operation but I think the pressure applied to it is very light and my impression is that it does not do a great deal of work.

Dr. Coates, (Louisiana State University):

The Hyatt Shredder was made in New Orleans and used in a diffusion plant at Baton Rouge. Every now and then some coupling-pins would get in with the cane and the mill was frequently shut down on account of this; otherwise, this shredder worked very well. The diffusion plant had to flush the bagasse into the Mississippi River, as the cost of drying it was thought to be more than the fuel value. I suspect that if a diffusion plant could use the fibre for making "Celotex", it would show a profit instead of a loss.

The "Searby" shredder at Glenwild is considered foolproof. I have seen pieces of iron go through this shredder without doing much damage.

Mr. McAllep:

This question of tramp iron was one of the determing factors in discarding the National shredder in Hawaii. I have seen the discs go to pieces on the National shredder; this would mean a shutt-down. The Searby shredder developed in Hawaii is seldom injured by iron. This shredder is now in use in large number of factories in many countries. It has been successfully operated here in Cuba, I believe. There are thirteen Searby shredders installed in eleven factories in Hawaii; they are giving excellent satisfaction. We can consider them as being fool-proof, so far as tramp iron is concerned.

I consider the Searby shredder an excellent device for evening up the feed to the mills. It enables you to have your mill filled up from the start. Shredded cane is already finely divided when it enters the first mill; without a shredder it is really not in condition for efficient milling until it has passed through several mills. The shredders add to both the capacity and the extraction. We can run at a good capacity and still get what is considered standard extraction in Hawaii.

A good many of the early Searby installations caused difficulty in keeping up steam. This was mostly due to the turbines that drove the shredders, for they were usually unnecessarily large, and were governed by throttling, so that the pressure in the steam chamber was only 20 to 35 pounds, and as they were exhausting against a back pressure of 5 to 7 pounds, their steam consumption was enormous. Much exhaust steam had to be blown off, necessitating extra fuel in many cases. I remember one turbine that originally had 14 or 15 nozzles; the engineer has finally plugged up most of them, and now is using only three or four or five nozzles according to the condition of the hammers. With this change they are getting along without steam trouble. It does not take an excessive amount of power to operate the shredders under normal conditions, and there will be no steam difficulties if this power is generated with reasonable efficiency.

In a number of tests on a shredder made both by Dr. Norris and myself, we obtained at the first mill more than 80% of the juice. The cane was fed directly to the shredder without previously passing through a crusher. The shredder was 54", succeeded by and 84" mill. The shredder does not cut down the capacity of the mill, rather it increases it.

Dr. P. Van Harreveld, (Java):

Two Searby shredders are working in Java, in both cases between the first mill and the second. The grinding rates in these two mills are about the same as in Hawaii. In the beginning the power required was very variable. It proved necessary to take out some of the bars to prevent waste of power, and then the shredders did good work. However, the feeling is that the shredder is not entirely necessary; the same result can be obtained from mills only, if you use the mills in an efficient manner. You can even leave out the crusher if you have a sufficiently good feed. If the mills are poor, then with the Searby they can do much better work; extraction is increased because the shredded cane takes more water. Without shredding, we cannot use more than 15% to 20% water on cane, but with shredding we can use more than 25%.

Mr. McAllep:

Running at a high grinding rate the Searby is a decided advantage. We have one mill in Hawaii running at a capacity somewhat near Cuban standards. This is a 72" mill, with a Krajewsky crusher, a Searby shredder and five 3-roll mills. It is grinding 80 to 90 tons per hour (150,000 to 170,000 arrobas per day) of cane having 13% fibre, and obtaining 97¼% sucrose extraction with about 30 maceration. You cannot get such results without an excellent feed at the first unit. You must obtain high juice extraction at the first mill.

A shredder must be well enclosed, otherwise the windage will consume considerable power and juice and trash will be blown out. None of the installations I have seen so far have been properly equipped to keep the casings clean. Shredded cane collects on the walls of the casing between the shredder and the first mill. It would be a very simple matter to put in something like a soot-blower to blow this out with steam overy few hours.

Dr. Ishida:

In Formosa we have quite a few Searby Shredders. At first they caused a reduction in capacity; then we decreased the number of hammers. Originally we had 48 hammers in a row; we decreased them to 24. At first we had installed the shredder ahead of the crusher; this also reduced the capacity, so we installed it behing the crusher.

We got 2% increase in sucrose extraction by the installation of the shredder.

Mr. McAllep:

Shredders came into vogue at about the same time as cane-knives and Messchaert grooves. The combined result of these three improvements was an increase of 3% or 4% in the averag esucrose extraction in Hawaii.

Mr. Semple:

Where the cane had a very high percentage of fibre, by reducing the number of hammers and making them 5/8" thick instead of 5/16", (the width remaining the same), they got comparatively good shredding work and smaller consumption of power.

Dr. Van Harreveld:

Two sets of hammers are used up in one crop. The price of these in Java is very high. Cheaper hammers were tried and found to be of poor quality; only hammers from the original makers did good work.

Mr. Phillips:

I would like to hear something about the inflation or swelling of the blanket of bagasse on passing through the Searby shredder. We have always had the idea here in Cuba that the cane leaving the Searby Shredder was so fluffy that it would occupy several times the volume of ordinary bagasse, and so render it impossible for the following mill to take the heavy feeds that we use in Cuba. What is the relative thickness of the blanket of cane leaving the shredder as compared to what it would be on leaving the first mill?

Mr. McAllep:

I cannot give you exact figures, but I know that if you allow the blanket to fluff up, it is pretty thick. Most installations on the Island have the shredder cane carried to the first mill on a belt conveyor. The head roll of the conveyor compresses the blanket of shredded cane against the top roll. The conveyor runs at about mill speed.

Mr. Semple:

There is in South Africa a 32″×66″ tandem of four mills and a crusher and shredder which averaged 53 short tons per hour, (100.000 arrobas per day) for the crop 1925-26. The cane had between 14% and 15% fibre, so the tonnage-fibre-ratio was higher than Vertientes' average for the same crop. The ratio figured out 31, as against 25½ or 26 for Vertientes.

Mr. A. J. Stuntz, (Havana):

The first "Maxwell" Shredder in Cuba is now operating at Central "España". This shredder differs from the other types in that it is attached to a crusher or a mill. The rolls of the crusher or mill hold the partially crushed cane while the shredder combs and cuts the cane as it is discarged slowly from the mill or crusher. The shredder itself consists of a cast iron roll, about 30 inches in diameter and 7 feet long, fitted on a steel shaft and carrying 441 alloy-steel sharp-edged teeth held in dovetails in the roll. It runs at about 400 RPM, and is driven by a 150 HP 900 RPM motor, through a "Texrope" drive.

The milling plant at Central "España" consisted of two tandems, each of a crusher and 6-36″×84″ mills. The first mill of one tandem only was converted into a "crusher-shredder" by installing the shredder roll in place of the bagasse roll. Thus the cane passes through the crusher and the remaining two first rolls of the first mill and is then shredded, then it passes on through the remaining five mills as usual. The mill setting of both tandems is as near alike as it was possible to get it. Nevertheless, even though we are getting one less pressing in the tandem than has the shredder, the sucrose extraction of this is considerably higher than the other tandem. We believe that when we get the mills in better shape to handle the shredded cane the shredder will give a marked increas ein extraction.

The usual amount of iron has passed through the shredder without much damage. The largest price of iron to pass the machine to date is a 1″ round bar about two feet long. This shredder has been shredding about 140 short tons per hour, (265,000 arrobas daily) since January 5th with very few stops and without any of the teeth being sharpened or replaced. The power being absorbed is still the same as it was when the machine was first started, that is from 75 to 80 HP. This indicates that this machine can be operated for a whole grinding season, under normal conditions, without replacing or sharpening the shredding teeth.

The blanket of bagasse formed by this shredder is very even and is not inflated, so that it feeds easily into the following mill without the necessity of using feed rolls or press rolls.

The advantages of this machine are as follows:

1. The mechanical construction of the machine is such that it can be operated for a whole season without reconditioning.
2. The cane is prepared for maceration by being finely divided, with a moderate expenditure of power.
3. The bagasse blanket produced by the shredder is easily handled by the following mills.

This explains why the shredder-equipped tandem gave better results and why it is reasonable to suppose that the present results are only the beginning of the improved work which will be gotten with this machine.

CRUSHERS

In Cuba crushers are more generally adopted than in any other country. Regarding advantages of the double or triple crushers over single crushers, may we hear from Prof. Kerr?

Professor E. W. Kerr (Cuba Cane Sugar Corp., Havana):

I am not prepared to say very much regarding milling. However, we are very much interested in the question of knives. In our calculations of grinding capacities we usually take each crusher roll as being equal to any other roll in the tandem for increasing capacity while maintaining our usual normal extraction. I think that we are all beginning to feel that we ought to look towards some of these other devices for increasing capacities; also that the knives, for the small amount of money they cost, ought to be a pretty good investment. It is true that we can get good extraction by using mills only, even without crushers, as in Javan practice. After all, it comes down to the question of how much our money does. I was hoping to hear a little more about knives. The knives are considerably cheaper than either the shredder or the crusher. We have alway used crushers and we are in the habit of thinking of them as the proper preparatory device for Cuba; they give large increase in grinding capacity, which was the thing that was wanted. However we feel that from now on we ought to increase extraction and I doubt very much if the crusher is going to do that.

Mr. Connon:

Tinguaro, in 1914, installed a 36″×84″ double-crusher in connection with a 36″×84″ 15-roll mill. It gave a very decided increase in grinding capacity.

Previously the maximum grinding-rate of a 36″×84″ mill had been considered to be about 160,000 arrobas per day (84 short tons per hour). Since that time there have been installed a great many double-crushers, and grinding-rates have been gradually increased until, three years ago, we considered 280,000 arrobas per day (148 T. C. H.) to be the limit of capacity of an 84″ mill. A triple crusher installed at Manatí, (I had the handling of this work and had advised against it), worked very satisfactorily and has ground up to 320,000 arrobas per day, (169 T. C. H.) I have never felt that the double or triple crusher was the best way to obtain larger capacities. In designing the new milling-tandem for Vertientes, we thought that by putting in cane-knives and one larger crusher we would get at least as great grinding capacity as with a double or triple crusher; actually the capacity proved to be greater than had ever been obtained in any one tandem. A set of "Ramsay" cane-knives was installed, then a 42″×87″ crusher and seven 36″ × 84″ mills. This tandem has ground 470,000 arrobas in one day (248 short tons per hour), which is a world's record for cane ground in a single tandem, also for cane-tonnage-ratio by any of the various formulas. The fibre was between 10½% and 11%, thus the fibre-tonnage-ratio works out a trifle higher than for the maximum week's grinding for the African tandem referred to by Mr. Semple (which I understand was 63 short tons per hour); but of course the fibre per hour per foot of length of roll is 60% greater, for Vertientes has eight milling units and the African tandem has five.

Mr. Camp:

In 1918 I was requested by General Goethals to submit ratings of various Cuba Cane Sugar Corporation plants, and was thereby confronted with the problem of establishing a rating for milling plants, as no formula suitable to Cuban conditions

and practice was available. To that end Mr. A. P. Leonard (now Consulting Engineer for the Rionda interests) and myself, made a rather extensive analysis of data that had been collected from mills in Cuba, Porto Rico and Santo Domingo, using only the records of such mills that were obtaining a sucrose extraction of 93% or better.

The result of that analysis was the point which Prof. Kerr made about the crusher being worth two rolls in the set. This perhaps answers also the unasked question which was brought to mnd by remarks on the Java practice. So many rolls give so much capacity, whether they be in the form of a crusher or mill. However, we found that the type of crusher grooving was an important factor in capacity This was determined especially by a study of the work done by the Fulotn crusher as compared to that of the Krajewsky type. We approached this study with an unbiased attitude. We were interested in the determination of the capacities of the various classes of equipment, and not the disparagement or aggrandizment of any particular line or design, but we found that the Fulton type of crusher with the heavy peripheral grooving showed a very much greater capacity than the zig-zag of Krajewsky type grooving. Therefore in our final formula we used a coefficient of 50 in determination of normal rating of plants provided with Fulton crusher, and a coefficient of 44,5 for crushers of the Krajewsky type. Even in this we made a little concession to the Krajewsky type, as the actual coefficient determined from our analysis was only 37. However we doubted that there could be such a large difference, and arbitrarely placed the coefficient for Krajewsky at 44.5. Now for eight years we have been watching the milling results as expressed in grinding coefficients, and it is interesting to note that very few plants equipped with the Krajewsky type crusher have even obtained the figure of 44.5. On the other hand, reference to the last report of the Sugar Club will show quite a few mills with Fulton type crushers which are operating with a grinding coefficient of 55 or 56, and obtaining 94 sucrose extraction or better.

The formula for determining what we call "normal capacity" states that this capacity (expressed in arrobas per day) is obtained by multiplying the number of rolls in the milling tandem (including all crushers and mills) by the diameter of the roll expressed in inches, by the length of the roll expressed in feet, and by the normal coefficient previously mentioned, namely 50 for those plants with Fulton type crushers and 44.5 for Krajewsky type crushers. Algebraically, this formula may be expreseed as "$A=N\times D\times L\times C$". For the purpose of checking this formula we have incorporated in all factory reports over which we had supervision, and also in the Sugar Club reports, the item of grinding coefficeint, which is determined by dividing the actual daily grinding rate in arrobas by the above formula, exclusive of the normal coefficient figure.

Now, as regards double crushers, while there was a tendency to make claim of very large increase in capacity due to the introduction of double crushers, we have not found that there is any change in relationship; an extra two roll crusher counts as two rolls in the train. However, there is an increased capacity due to the very heavy grooving now being used in the "splitting type" (Fulton type) crushers. We are now using grooving of 3″ to 4″ pitch in the pre-crusher of a double crusher unit; this year ther are three such plants with rolls 42″ in diameter. Figure out the difference in peripheral speed between the base of the groove and the point, and you will see that there must be considerable shearing action taking place, with

the result that the cane fibres or bundles are torn asunder, and put in a much better prepared condition for feedin to the succeeding rolls.

If we were grinding at the rates used in Java the rolls would be set practically iron to iron, and I believe that we would find that the cane would pass out in a condition very similar to that discharged from a shredder. At least the action of the crusher would approach that of the Newell shredder but operating at a slower speed.

As I have already described, the principle of the old shredder was simply the longitudinal shearing of the cane. The Newell shredder roll was not vastly dissimilar in appearance from the modern Fulton crusher roll. The grooves were of 6″ depth, as compared to 5″ to 4½″ depth on the crusher, so that when you get right down to it you can almost consider this type of crusher as a slow-moving shredder. Barring the damage that might be done by iron, the larger gooving will probably last six or seven years. I recall roll of 2½″ grooves that required reshelling after seven years.

As I understand it, the three-roll crusher in Hawaii is simply an ordinary cane mill with very heavy roll-grooving. The practice of using very coarse grooving on the first mills is rapidly developing in Cuba. Following the impulse given by Mr. Connon, we have gone in for 1½″ grooves on the first mill. We started in about 1916 with a sort of bastard groove, using old rolls with 2½″ groves to the inch; we converted them to grooves of 4/5″ pitch. That was the beginning of coarse grooving here in Cuba. Cape Cruz is one of the mills that approaces Hawaiian conditions; they have an eleven-roll seven-foot mill grinding 80,000 arrobas a day, (42.2 tons per hour), with 1″ grooving on the first mill. This is the nearest thing we have had to a Hawaiian three-roll crusher.

Note by Secretary: Vertientes, calculating the knives as two rolls, has reached a coefficient of 74.

Mr. M. Galainena (Cuba Cane Sugar Corporation, Havana):

The difficulty we have experienced in obtaining grinding capacity is due more or less to speed. At "Lugareño" we have a crusher (furnished by Harvey) with rolls by Fulton of 1¾″ pitch. There we experienced considerable choking of the first mill. We had trouble in getting the proper cane preparation with the desired capacity, the crusher speed being 29 ft per minute. It was thought that the trouble was in the pitch of the grooving on the roll, so we changed the pitch from 1¾″ to 2¾″, but this did not help much. The capacity was increased only 5% or 6%. Last year, with Prof. Kerr, decided to change the gears on the crusher so as to run it at 48 feet per minute instead of 29; the consequence was that instead of our former rate of about 190,000 arrobas per day (100 tons per hour) we are today grinding 248,000 arrobas (131 tons per hour) and besides we are getting higher extraction.

Another factory, "Perseverancia", is grinding 320,000 arrobas per day (169 tons per hour). When we first started we had ¾″ opening on a 3½″ pitch Fulton crusher, running at 46 to 48 feet perminute; after 2½ weeks operation we found that we had to close up the crusher because it was choking the first mill. By closing up the crusher we got better feeding of the first mill as well as greater first mill extraction. We have not run any tests on extraction done by the crusher and first mill, but anyone standing on the mill platform could see that the cane was very well prepared. I think that the main trouble we have had with the Krajewsky type

is due to running too slow; if we check up on the Krajewsky crushers, we see that the peripheral speeds are very low.

Mr. Camp:

The tendency in 1916 and throughout the war period was to put in Fulton milling plants, so that the mills of that type which were used in the deduction of our formula were undoubtedly more modern that those of the Krajewsky. However, we do not believe that speed alone caused the fundamental difference expressed in our formula. As regards speed, the tendency has been for fifteen years to increase crusher speed in relation to the following mills; at Manatí, since its construction in 1914 they have twice changed the crusher gearing to attain higher peripheral speed, and today the practice is to use a crusher speed approximately 20% greater than that of the first mill, instead of 8% greater as on the original Manatí installation.

The older types Krajewsky installations follow that older practice of the Fulton —that is to say, the crusher is operated at a speed approximating, or slightly in excess of that of the first mill. But many of these Krajewsky type installations have an independent engine driving the crusher, and we made many experiments speeding up the crusher in an attempt to attain a capacity rating similar to that obtained by the Fulton type crusher. We gave a great deal of study to the question, and finally, becoming convinced that the Fulton type crusher gave a materially greater capacity, we ordered practically all of the plants of the Cuba Cane Sugar Corp. which were equipped with Krajewsky type crushers to replace the old shells with Fulton type shells. This was done, as I said, after making several tests of Krajewsky independently-driven crushers operating at higher speeds. The high speed gave better results, but did not compensate for the difference which we found existing between the two types.

In converting the Krajewsky crushers to the Fulton type we at first experienced considerable difficulty in obtaining satisfactory feeding from the cane chute, and found that it was necessary to lower the bottom of chute in order to get satisfactory feeding. Normally the chutes of Krajewsky type crushers are so constructed that a line projected from the bottom plate will intersect a line cutting the axes of the two rolls at a point about 4″ above the center of the bottom roll; whereas to get satisfactory feed with Fulton type rolls it is necessary that this projected line cut the center line at a point approximately 8″ below the center of bottom roll. This apparently is a fundamental condition for satisfactory feeding.

Mr. Semple:

With regard to the position of the chute, in Hawaii we found that the chute should touch the lower roll from 6″ to 8″ ahead of its vertical center. That is, the horizontal distance from the top of the roll to the point of contact of the chute with the roll surface should be 6″ or 8″.

Hawaiian experience coincides more or less with Cuban experience on this point.

Note by Secretary: This will place the chute in a position much higher than that specified by Mr. Camp.

Mr. Connon:

With regard to the surface speed of crushers, I do not know what the upper limit is. The crusher at Vertientes has a surface speed of 46 ft. per minute, I believe we can run crushers at very much higher speeds yet, possibly as 55 or 60 feet per minute.

Mr. Weil (Havana representative of Cie. Cail, France):

A different style of crusher grooving the "Cail" system has recently been installed at Central "Hershey", the first instalation in Cuba. It has the general appearance of Krajewsky, but works on a different principle; it is designed especially to extract juice as well as to break up the cane. The grooving is about 6" peripheral pitch, and the zig-zags are about 4" long measured parallel to the axis of the shaft. The two rolls mesh closely together, that is to say the space between the rolls is parallel instead of having hollows as has the Krajewsky. This effect is obtained by making the teeth V-shaped, with about ½" flat at the point and 1" flat between adjacent teeth at the root. At each point of the sigzags (i. e., at a pitch of 4") there is a deep juice-groove similar to the Messchaert, about 5/16" wide; this carries away the expressed juice and so prevents the crushed cane from reabsorbing it.

At "Hershey" this is used as a second crusher, the first one being of the Fulton type with 3" pitch teeth. Last year a test of juice extraction was made to compare the two types of crusher. The juice extracted by the first crusher was 32% of the weight of the cane. Then the first crusher was removed, and the "Cail" crusher was found to extract 51% of the weight of the cane.

Mr. McAllep:

In Hawaii most of the Searby shredder installations are preceeded by Krajewsky crushers. Mr. Searby himself is much in favor of the Krajewsky type of crusher as a feeding device. In the last few years nearly all the Krajewsky crushers have had Messchaert grooves, cut in them to drain the juice from the pockets formed by the points of the sigzags; this has made considerable improvement. The tendency has been very much toward higher speed of the crusher rolls in these installations.

We have some two-roller Fulton crushers and some Krajewsky, but the tendency in recent years is toward 3-roll crushers. With these we can get a very good disintegrating action and good juice extraction at what I would roughly estimate as about 2/3 of standard Cuban capacity. Some of them are 1¼" and some 1½" pitch grooving; 60° teeth are used on all rolls. Now with these three-roll crushers, preceeded by cane-knives, under these conditions 72% to 77% of the total juice can be extracted in one 3-roll crusher.

I think that with either Fulton type or Krajewsky if we get 50% of the juice at the crusher it is excellent work; I have seen it as low as 15% or 20% of the juice. The efficiency of the 3-roll crusher decreases somewhat as the angle of the grooving flattens with use.

The mills in the Hawaiian Islands work principally for the extraction, having more than enough capacity to grind all the cane available. The latest tandem built in the Islands has a 3-roll crusher and 9-roll mill; the setting of the 3-roll crusher will be, on the discharge-side, about 1/8" opening from the tip to the bottom of the grooving, and on the feed-side a maximum of say 3/8".

This particular mill has averaged between 98½% and 99% extraction during three or four years it has been in operation, carrying about 75 tons to 80 tons hydraulic pressure per foot of lenght of roll. When a mill does not have to be operated at too high a capacity I personally favor a 3-roll crusher preceeded by a set of knives rather than any other equipment.

Our tandem at Central "Perseverancia" consists of seven mills with one 2-roll crusher. The first mill has 2" grooves, the top roll having longitudinal grooves, the second mill has 1½" grooves, also with longitudinal grooves on the top roll. The

capacity is normally about 320,000 arrobas per day (169 tons per hour), the sucrose extraction being 95% to 96%. The first mill runs about 32 feet per minute, the second mill 29.

Mr. Semple:

The three-roll crusher mentioned by Mr. McAllep is interesting.

In 1919 the Hawaiian Sugar Planters built a new factory and got the best talent to make the specifications for it. They specified a 15-roll mill, but called it a 12-roll mill with a 3-roll crusher. They had come to a conclusion in Hawaii that the 3-roll crusher was the best method of getting the juice out of the cane.

Mr. Connon:

There is a three-roll crusher at Central "Portugalete" preceeded only by a set of knives placed 3½" from the carrier slats. The mill is 34"×78" and grinds about 175,000 arrobas of cane per day (92,5 tons per hour). The 3-roll crusher takes the feed without any trouble and could grind more cane if necessary.

GROOVING

Mr. Connon:

To get the large grinding-capacities that we obtain here in Cuba we find that we have to fit the first mill, and sometimes the second, with large grooves. The "Vertientes mill, which is handling the largest tonnage of any; has one set of revolving knives set about 12" away from the slats, and one crusher 42" diameter with 3" pitch Fulton type grooving; the first mill has 2" pitch grooving, the second mill 1½", the third and fourth 1", the last three mills ½" on top and back rolls. The first three mills have longitudinal grooves similar to those of the Fulton type crusher, spaced 6" or 7" apart.

The contained angle of the grooving on all the mills is 55°; we have standardized on this angle in Cuba. We attribute the large capacity of the mill to the heavy grooving.

Mr. Clayton: Our rolls are usually grooved 0.66" pitch, with 33° contained anglo; the grooves are 15/16" deep, and the points of the ridge 1/16" wide.

We do not experience any serious difficulty due to the breaking away of the ridges between the grooves. We tried 30° angle grooving on 1" pitch with a flat top about ¼" wide; the rolls were of cast iron as usual, and the surface soon got in very bad condition.

Sometime ago cast steel rollers were tried with Hind grooving (30°); they were smooth as glass but would take any feed you could give them and up to 100% maceration. These rolls were not very successful for accidental iron would bend the teeth over a little bit to the grooves and the bent tooth would knoock a tooth off the trash knives.

Mr. Camp:

In the Cuba Cane mills we started out with 45° contained angle but finally deetrmined that 55° was the most suitable for grooving of 1" pitch. In the smallest grooving, that is to say ½" pitch or smaller, the 45° sharp edge was the most suitable although it wates down pretty rapidly. The sharper groove gives better drainage and also greater attrition.

Mr. Sample:

I believe that the reason why the very deep groove is used In Australia is on account of the large percentage of maceration water. The mills also have pusher feeders in most cases.

Mr. Chisholm:

We had a 15-roll tandem with grooving of 45° contained angle and ½" pitch, with Messchaert juice-grooves. Whenever one of these rolls wore out it was replaced by a roll having 60° angle, until now, all the rolls have 60° grooving, ½" pitch, the sucrose extraction is now 0.5% to 0.6% less than it was when the grooving Although the mill has been in charge of the same operation during all this time, was 45°.

Mr. McAllep:

In one mill that is running somewhere near Cuban capacity the grooving on the first mill is ¾" pitch, and either 55° or 60°, with all grooves meshings; the other mills have 7 grooves per inch on the top and back rolls and ¾" pitch groove on the front roll. This is quite standard practice in Hawaii for the mills running at high capacity, particularly when grinding the softer canes. Caledonia cane has a strong fibre; you can get this cane to the place where you can put pressure on it even without having ¾" grooving on the feed roll.

Mr. Camp:

In Cuba we have inclined to the practice of ½" pitch as the limit of spacing of feed-roll grooving, this limit being established by the question of trash-knives (or turn-plates, as we term them) it being found that the wear-down with heavier grooving is so great that the turn-plate cannot withstand throughout the crop. We believe that this grooving best serves our purposes when rolls are not provided with Messchaert juice channels. With Messchaert grooves, if they are not spaced at a greater distance than 3", more satisfactory results are obtained with grooving of 1/3" or ¼" pitch, permitting the expressed juice to more readily reach the Messchaert channels. Where a heavy grinding-rate is sought, it is common practice to groove the top and bagasse roll of the first mill, and sometimes also of the second mill, with 1" or even 1½" pitch. Other mills of the train are usually grooved ½" pitch throughout.

We have tried to adhere to a standard of grooving so that our rolls might be interchangeable throughout the train, exceptin, of course, the coarse-grooved rolls of the first mill.

As regards the heavy grooving in the first mill, our early experience was very unsatisfactory due to failure on the part of the mill-engineers to recognize the importance of compensating for the volume of the grooves when determining the mill settings. At one mill the engineer had for years followed the practice of setting the discharge opening at ½ of the feed opening; this practice is bad enough with rough ungrooved rolls such as were commonly used twenty years ago, but with the combination of ½" grooving on the feed roll and 1" on the top and back rolls, this rule gave an actual net discharge opening 87% of the net feed opening. That is one of the many difficulties we have encountered with the old school "practical engineer" that we so often find here.

It has been my practice to set the back rolls very close and depend upon the hydraulics to provide the required discharge opening as varying fibre contitions may demand.

The actual requirements, of course, vary almost every minute, but analyzing the setting of those Cuban mills which were obtaining good extraction results with high capacity (that is, those mill reports that we used in determination of the "normal capacity rating") we found that the net feed opening of the first mill averaged 0.70 sq. in. per 100 arrobas of cane ground per 24 hours in Fulton type crushe

units and 0.85 sq. in. in Krajewsky type crusher units. From this data we constructed a chart for the setting of mills at the various grinding rates. Surface speed was not taken into consideration as that is a variable which can usually be adjusted. It may be of interest to see some of the figures we have worked out. It is very important to take the grooving area into consideration when determining the mill openings.

Dr. Van Harreveld:

In Java we use grooves of different types in the rolls. We experimented with the Messchaert grooving some time ago, but did not get good results and so abandoned it. Last year some factories started again experimenting with Messchaert grooving and are not getting better results.

Mr. McAllep:

Messchaert grooves properly installed ought to make a difference of 5% in the moisture of the bagassee leaving the mill. In Hawaii they were developed in 1912 or 1913 by Mr. Messchaert to make his mill feed properly. The grooves were originally cut in the feed roll as a feeding device and accomplished this object very well. Then the engineers tightend up the mills, using iron-to-iron dsicharge-settings and close feed-settings, and so obtained increased extraction; before Messchaert grooves were used the usual extraction was only 93% to 94%. In Hawaii all lower rolls except some of the first-mill feed-rolls have Messchaert grooves.

It took a great deal of experimenting to get the proper pitch and dimensions for the Messchaert grooves. V-shaped grooves have been tried, but they do not give nearly as good results. The pitch of Messchaert grooves should be as small as practicable, say 3″ on ¾″ grooved feed-rolls or preferably 2″ where the grooving permits. They should be at least 1¼″ deep; 1¾″ is better. ¼″ is a good width for feed-rolls, 1/8″ for back rolls.

Mr. Semple:

That the Messchaert groove helps to take the moisture out of the bagasse, was my experience at Hilo, Hawaii. We used to run the engine of the last mill at 50 RPM and the average moisture in the bagasse was 45% to 46%. After Messchaert grooves were installed (I should say two or three years later, by which time we had obtained experience in the operation of these grooves) the speed of this engine was reduced to 30 RPM. The average moisture in bagasee for the season was 37% to 38%. The moisture in bagasse cannot be reduced by simply cutting grooves; the mills must be set up hard to accomplish this.

The Application of Pressure to Mills.

Mr. Semple:

There are three main types of pressure application, vis, hydraulic regulators, toggle regulators and rigid or solid housings without relief.

Mr. Connon:

Hydraulic regulators are used on practically all of the mills here in Cuba; this may be considered standard practice. There are e few crushers, and there may be a few mills that have the toggle type of regulator but there are not many in use.

I underatand also that all the mills in the Hawaiian Islands are fitted with hydraulic regulators.

Mr. Del Valle:

The same thing applies to Porto Rico.

Mr. Clayton:

In recent installations in Australia we have put in hydraulic regulators; the earlier mills are solid.

Mr. Semple:

In mills equipped with hydraulic regulators, the details of the mechanism for transmitting the pressure from the hydraulic accumulator to the top roll are quite important.

It is in the minds of most of us from Hawaii that the hydraulic regulators in the Cuban Mills appear dead; in Hawaii they are floating and riding much more freely than they are here. In some of the older installation of hydraulic regulators it was the custom to put in a washer with a 1/8″ orifice in it to prevent too sudden action of the accumulator or the mill if something broke; I have seen that system in use up to fairly recent times. My own impression is that, on the contrary, we should have as large a pipe connection as possible from the hydraulic jack to the accumulator. Another important question is the point of application of the hydraulic pressure to the top brass. If the pressure is applied on the center-line of the mill, the top brass has a tendency to cant and jam in the headstock and so prevent the roll from lifting.

Mr. McAllep:

This is a subject which interests me very keenly. As you know, in Hawaii we have obtained our high extractions by the application of pressure. I have heard it stated many times that on account of the high grinding-rates in Cuban mills the moisture in bagasse cannot be reduced to low figures. I am most curious to know just to what extent these conditions exist. I have had a bit of an oportunity to study milling in Hawaii and the way the engineers were handling the matter. Aside from the maceration and various other details we can divide our problem of obtaining high extractions into two parts, first, getting our material to the point where we can apply pressure, second, applying heavy pressure between the top roll and the back roll. It is our experience that if you can get the cane into the mill against a high pressure, with proper drainage conditions on the rolls, and can then apply a heavy pressure, the bagasse will emerge at a low moisture content. I can readily understand that in grinding at too high a rate you might exceed the juice capacity of the Messchaert grooves. At present in Hawaii we are getting, in the better operated mills, from 70 to 80 tons pressure per lineal ft. of roll on the cane; this is close to the limit at which the cane will refuse to enter the mill. Moreover, if we increase the pressure beyond 80 tons per ft. with our present equipment we begin to break shafts and tear things up a little bit generally. The Messchaert grooves have been one deciding factor in being able to get the cane into the mill against a high pressure, also in reducing moisture when running at high capacity using ¾″ pitch grooving on feed rolls and fine grooving (4, 5 or 6 per inch) on bagasse rolls.

Mr. Del Valle:

Porto Rican practice has followed Hawaiian practice fairly closely. We find Messchaert grooves very necessary. In fact two years ago a number of us tried using two grooves to the inch on all the rolls of the mill but is proved impossible to get the same work and we had to go back to the Messchaert grooves. On the Island of Porto Rico we have increased our extraction 2 to 3%. We too use 80 tons per lineal foot and sometimes more.

Mr. Van Harreveld:

As for Java, most of the mills use hydraulic pressure; there are however a small number of factories that have solid mills; toggles are often used on the crusher. In Java there are two distinct methods of operating the hydraulic pressure mills. One method is that the top roll is riding, as in Hawaii and elsewhere, so that the pressure is just what you read on your meter. The other method (used by a company which gets very good extraction), is to use such a low hydraulic pressure that the top roll usually works at the topmost point of its possible travel, the mill then working like a solid one. In this system the hydraulic merely serves to close up the mill when the fedd is very light for a few minutes. This company has strong steel housing with very large shafts in the rolls, even using special steel, so that they can apply high pressure if their feeding is very uniform. Since the mill works like a rigid mill, they have to feed uniformly and strongly to get heavy pressure.

Prof. Kerr:

With regard to the relative pressures on the different mills, i. e. whether the heaviest pressure should be on the first mill or the last, there is a great deal of difference in practice here in Cuba. Some people use higher pressure in the first mill on the supposition that we need more pressure early in the process in order to break up the cells so that the maceration can penetrate as much as possible. A great many factories use the other system, applying the highest pressure on the last mill on the supposition that the thing that really counts is heavy squeezing of the bagasse immediately before and after maceration.

Mr. Del Valle:

In Porto Rico we apply heavy pressure in the first mill. We try to get as much out of the cane as quickly as possible, getting the juice at the earliest stages so that we can perform better maceration. We sometimes carry 90 tons to the lineal ft. in the first mill, carrying 80 tons on all the others.

Mr. Clayton:

Most of our mills in Australia are solid mills, so I doubt if we can tell actually what pressure we are putting on them.

Mr. Van Harreveld:

Some of the mills in Java use higher pressure on the first mill and others on the last mill; there is no universal rule in this matter.

Mr. McAllep:

I think that we find somewhat the same result in our Hawaiian factories. We feel that to get good extraction we must apply all the pressure we can at all points. It is mistake to slack up on your pressure and not to get all you can at the head end of the train. I think that our high extractions are to a very considerable extent due to what I have heard some of our engineers term "hitting it early", that is getting extraction of about 80% with the crusher and first mill. This refers, of course, to moderate grinding rates. If you get that much with the crusher and first mill of a 12-roll train, and can then put on about 30% maceration. There is not very much trouble in getting 98% sucrose extraction.

Mr. Van Harreveld:

The "nitrogen accumulator" now has come into practice in Java; it consists of steel flasks with compressed nitrogen gas. The installation takes up very little room,

and is easy to manipulate, because the valves of the jacks of all the mills can be placed close together.

Mr. Semple:

One of these nitrogen accumulators has been installed in Mauritius.

INTERMEDIATE CARRIERS

Mr. Connon:

The apron type intermediate carrier, the scraper or Ewart type and the Meinecke shute are all in use here in Cuba, the apron type being the most common. The Erwart carriers were first used in Cuba about 1920; they are now in use in about 16 factories.

Mr. Bennet:

The universal system in Australia is to have a large bath or tank of water between successive mills through which the bagasse is dragged very slowly. Since this is so completely different from the usual system of intermediate carriers a full description will be reserved until we come to the subject of "Imbibition vs. Maceration."

Mr. McAllep:

The old apron or slat type conveyor has been entirely discarded in Hawaii. They have been replaced by the Meinecke chute, by the Ewart type, and by the Ramsay type (which latter is similar to the Ewart but placed at an angle). With the Meinecke type, maceration was at first unsatisfactory and it seemed as if good extraction might be difficult to obtain; but now maceration is applied just as the bagasse emerges from the mill. A certain 12-roll mill equipped with Meinecke conveyors has averaged 99% extraction for an entire season. Attributing low extraction to Meinecke conveyors can hardly be justified. Mill sanitation, easier upkeep, and convenience in replacing the acrapers of the Messchaert grooves, have been factors resulting in the installation of Ewart, Ramsay and Meinecke conveyors.

Mr. Connon:

The new mill at Vertientes has Ewart carriers and is grinding at a higher rate than any other mill that I know of. The carriers there have been very satisfactory. They had to be modified to suit the heavy grinding but after that they gave little trouble.

IMBIBITION VS. MACERATION

Mr. Semple:

Strictly speaking, by "imbibition" we understand the system used in Cuba, Hawaii, and most other countries, i. e. simply spraying or pouring of dilute juice or water on the bagasse; "Maceration" is the method used in Australia where the bagasse is drawn through a bath of water or dilute juice, in which it is totally submerged. However, I notice that in Cuba and Hawaii the process of imbibiiton is usually called by the name of "maceration".

Mr. Connon:

Some factories here in Cuba use hot water, 150° to 200° F.; many prefer warm water 110° to 120° F. The water used is in all cases "sweet water", i. e. condensate from the last cells of the evaporator. May we hear from the delegates of the other countries as to their practice in this respect?

Mr. Kerr:

The Cuba Cane Sugar Corp. factories use fairly hot water. The sweet water from the evaporators is the easiest to get, and is pure. The usual amount of imbibition water is about 15% of the weight of the cane.

Mr. Del Valle:

In one factory in Porto Rico we had to stop, because of the "gumming" disease; the application of hot water made conditions worse. To check the gumming we had to use cold instead of hot water. This was the only time I have seen cold water used.

Mr. Semple:

It has always been my experience to use hot water; the only reason was that we found a slight falling off in extraction with cold water. This is quite general in Hawaii, I believe.

Mr. Van Harreveld:

In Java most of the factories still use cold water for imbibition. Recently several factories have been using hot water and have obtained a distinct increase in extraction. I consider it better to use hot water.

Mr. McAllep:

One advantage of using hot water for imbibition is that it prevents bacterial growth around the last mills. We have made a fairly complete survey of our Hawaiian mills for thermophylic organisms, and the highest temperature at which we have found growth is 162° F. Therefore if the temperature of the liquids is kept above that you will certainly have no development of organisms in the vegetative state. In the neighborhood of 170° F. inversion velocity is almost infinitestimally slow, so loss by inversion need not be feared.

Mr. Connon:

The usual practice here in Cuba is to apply the inmbibition water either at the last mill or at the last two mills, depending on the number of the mills in the train. The dilute juice extracted from the mills receiving this water is returned and used for imbibition on the first mills, being sometimes returned as many as three times on the longer trains; this is what is commonly known as compound or triple maceration (or imbibition). The standard practice here is to apply the water to the bagasse just as it emerges from the mill; it is usually sprayed under the top scraper, so that it enters the central part of the layer of bagasse. In some cases the water is applied to the bagasse just as it enters the mill; the advantage of this is that the bagasse does not have time to swell, and thus the danger of the mill chocking is reduced. It is claimed that with the latter method just as high an extraction can be obtained as by applying the water behind the mills.

Mr. Van Harreveld:

As for true maceration, we have tried to do what some Australian factories have been doing; their extraction was much better than ours and we could only find the cause in their maceration system. We tried this system and immediately got good results. In Australian maceration the water works for a considerable time on the bagasse, possibly twenty minutes. This is simply a question of being able to store all the bagasse coming from a mill during that time before sending it to the next mill. For that purpose the distance between successive mills is in Australia 40 to 60 feet. In Java we have only 30 feet distance, so we can store the bagasse

for only about 8 minutes; this we consider enough to get good results. We have developed a form of apparatus which stores the bagasse for 8 minutes in a layer three feet thick, and causes the water or diluted juice to percolate through this thick layer of bagasse over and over again. This is done by keeping an excess quantity of water or dilute juice between the mills, and by means of pumps of large capacity circulating it through the bagasse. That is to say, we pump on top of the bagasse far more liquid than it can absorb; then the excess percolates through the layer of bagasse, returns to the pump, and is again pumped up to the bagasse. On each carrier the liquid is applied in three places, overflowing from one to the next.

Besides compelling the bagasse to absorb all the liquid possible, this system causes the most complete admixture of the applied liquid with the juice that was contained in the bagasse, and, so obtain high "efficiency of maceration". It is simply an application of the principle of "leaching".

With this system we have reduced the loss of sucrose in bagasse to 60% of what it was before installing the system. The same factory has now installed this system between another pair of mills and thus expects this year to reduce the loss in bagasse to the lowest possible figure. Three other mills are installing the system for the next grinding season, and many others will follow.

We use in maceration the same amount of water as Cuba, 15% to 20% on cane. I have seen Hawaiian figures for common imbibition that come up to even 40%; Australia uses for maceration 40% water on cane; but for our installations it is not necesasry to increase the amount of water beyond what was formerly used. The water is heated to 80° C., so we have complete sterilization on our last mills. Lime is added authomatically, in just such quantity that the juice remains slightly acid. By the filtration of the last mill juice through the bagasse the brightness of this juice was improved and there was no bad influence in the boiling house. On account of the very wet bagasse we have put in a fourth roll about 10″ on the last mill.

Mr. Semple:

There seems to be a distinct tendency towards diffusion of one sort or another. One company installed a continuous beet diffuser between the two last mills as an experiment. In some countries the idea is to wash out the sugar with a repeated number of comparatively light pressings. In Hawaii they squeeze it out by heavy pressure.

Mr. McAllep:

One mill in Hawaii put in macerating baths like those used in Australia. But because of our high mill-pressure and Messchaert grooves, the bagasse entered the bath in such a dry state that it simply took up the water like a sponge and the macerating baths remained dry. When high pressures are efficiently applied it is seldom that all the bagasse can be wet with 30% or 40% maceration. In fact when I cannot find any dry spots in the feed it arouses the suspicion that the preceding mill has not been doing efficent work.

One reason why it seems absolutely necessary to get extraction early in the milling is so that the later juices shall be low Brix. The effciency of our imbibition in Hawaii is very low. A few experiments have been made, but aside from the use of hot water the experiments have not led to success so far.

Much of the imbibition in Hawaii is from both beneath and above the bagasse. A good many mills have "Ramsay" "macerating scrapers" in which imbibition is applied under pressure before the bagasse is allowed to expand. With the "mace-

ration scraper" and the use of steam injection, the steam entering seems to penetrate throughout the bagasse better than water alone.

Mr. Coates:

A couple of years ago a man whom I knew and who had had considerable experience in Cuba had some hollow turn-plates made with orifices for forcing live steam into the bagasse; installed them in our experimental mill. We had previously obtained a juice extraction of possibly 76, and after putting in the live steam injection it went up to 84. The introduction of live steam through hollow turn-plates has several advantages. It reduces the internal coefficient of friction of the juice (viscosity) so that the juice gets out faster from the point at which the pressure is applied on the next mill; this is a great point in reducing reabsorbtion. Another benefit is that the steam replaces the air in the interstices of the bagasse, then it condenses and pulls the water down into the body of the bagasse. This man took sick that very Spring and died and the experiment lapsed.

Mr. Kerr:

In Cuba the large grinding-rate at which we run our mills makes it difficult to get the water (or the juice, which-ever it may be) to permeate the entire layer of bagasse, which as you know is very thick, even 12″ in our very heaviest grinding mills. Such a very large volume would also make it much more diffcult to apply the bath system. We are trying to make a study of how to best utilize our present methods by applying the water to the bagasse from below as well as from above.

Mr. Arango:

At Andora we are using a "maceration roller" to press the bagasse after applying the imbibition. These rollers are 25″ in diameter; they weigh 4 tons and are held down by springs. We return the 4th mill juice to the 3rd mill, and the 3rd to the 2nd. With 40% maceration the water goes all the way through; when you look into the blanket you can see that it is very wet and sometimes you can squeeze juice from it. We find that this has improved our extraction 0,5%.

Mr. N. Bennet (Queensland, Australia):

Bath maceration of bagasse as used in Queensland, requires a closed casing or tank between the mills, V-shaped in longitudinal section. The mills are 40′ to 60′ apart, center to center. The floor of the casing slope steeply down from the discharging mill for a length of about 7′, then rises gradually to the following mill.

The conveyor arrangement within casing is of the common scraper or drag type, the usual arrangement being T-iron flights attached to three stands of conveyor chainlinks at about at about two feet pitch, and pointed individual scrapers attached to the T-irons. This conveyor runs on a cylindrical closed drum (diameter up to 10 ft. with teeth at the two ends and in the middle. At the entrance to the following mill the conveyor-links mesh on sprocket-wheels of the usual type. The closed drum is driven slowly from the succeeding mill. The casing is filled with water or dilute juice to a depth 3½ or 4 feet, at which level there is an overflow to discharge the excess, if any, back to the bed of the discharging mill. The closed drum thus holds the bagasse down beneath the surface of the liquid.

As the macerated bagasse is dragged out of the bath proper it passes over drainage trays which permit excess maceration carried up with the bagasse to return to the bath. In spite of this, the bagasse discharged into the feed mill contains from 75% to 80 water and gives trouble in feeding unless assisted by a pusher. Most

mills use a pusher; this is a heavy flat bar extending the full width of the mill and having an edge 4" to 6" thick; it is driven with a powerful reciprocating motion that forces the bagasse portion by portion directly into the opening between the front and top rolls of the mill. It is actually powerful enough to squeeze out a considerable amount of the liquid from the bagasse.

No mill grinds more than 55 long tons per hour (61,6 short tons; 117,000 arrobas per day); the time taken in conveying the bagasse through the bath varies from 10 to 20 minutes according to the distance between the mills.

This type of maceration-bath and conveyor has been in use for 30 years; in factories when attention is given to adequate milling of the macerated bagasse, sucrose extractions of 99% and over have been recorded with the sets of knives, a disc shredder and four 3-roll mills.

Owing to the methods of control, it is difficult to translate our terms for dilution to those in use elsewhere, the more so as no factories weigh juice leaving the mills. In terms of evaporator supply (calculated from the Brix ratios of the first extracted juice and evaporators supply juice) the figures vary from 220 to 260 Imperial gallers per long ton of cane (i. e. 104% to 123% on cane).

When properly operated, the amount of macerating fluids entering the bath should be sufficient to maintain a fully saturated bagasse and allow of no overflow.

The liquid in the bath is kept heated to above 190° by means of steam, thus fermentation is prevented. In mills using the Petree process, the returned mud makes the bath sufficiently alkaline to prevent inversion. No trouble due to gums has been noticed.

Not all of the Queensland mills are obtaining high extractions with this method; I think this is due to not pressing the bagasse in the mills to the same extent as is done by the Colonial Sugar Refining Company, which is obtaining 98% to 99% sucrose extraction. Other mills are finding it extremely difficult to get more than 96% extraction because they do not use enough hydraulic pressure on the mills, nor enough power to drive them. Using the maceration bath between the second mill and the third, it is essential that you obtain 83% to 85% sucrose extraction with the crusher, (if any) and first mill.

If the sucrose extraction of the first mill falls below 80% it is almost impossible to get a total sucrose extraction over 96%. You must understand that this maceration process is applied to a cane that has had ample pressure applied to it at the first mill. The success of the operation also depends upon efficient milling of the bagasse after treatment by the maceration process.

Note by Secretary: The average percentage of fibre in cane being about 10½, figures indicate that the added water is 25% to 44% on cane. A calculation based on the statement that the macerated bagasse contains 75% to 80% water, and assuming that the bagasse enters the bath with 50% water, indicates that the added water is 21% to 32%.

JUICE STRAINERS AND MILL SANITATION

Mr. Connon:

The typical juice-strainer used in Cuba is the ordinary drag-type conveyor with wood slats or scrapers running over perforated screens mounted on removable frames. It is usually placed a longside the mills. We developed a new design for the Vertientes factory to obtain large capacity and obviate dragging the bagacillo of cush-cush from the later mills through the more concentrated juice coming from earlier

ones. In this design the strainers are placed between the mills, and all discharge their bagacillo into a drag conveyor that runs alongside the mills.

Mr. Clayton:

Our juice strainers are generally similar to the typical sort described by Mr. Connon, but as the tanks for mixed juice and maceration are often some little distance from the mills the screens are supported on stump columns from the floor of a shallow pit with plenty of clearance below and on both sides to facilitate cleaning. The screens are mounted on removable trays which can be withdrawn from the side of the trough and replaced in a few seconds.

Mr. McAllep:

In Hawaii most of our juice screens follow more or less closely the typical Cuban style. These are a source of loss of sucrose, for they form a place of excellent incubation for micro-organisms. In a few factories they have one side open so the other side of the screen can be brushed. In other factories they have steam-pipes to steam out at more or less regular intervals. Steaming under these conditions is not sufficient to kill bacteria unless the flow of juice be stopped. At our last mills, where the juice is hot, the mill is quite clean. In making tests at different mills we have checked up sanitation indirectly by titrating the juice from different mills and calculating the acidity as a percentage of the solids. The juice from the crusher and first mill is mostly from the pith of the cane; at later mills the rind juice is obtained, which is more acid. The natural increase in acidity due to this cause, from the first mill to the last, is perhaps 100%. If sanitation is poor, the increase may be as much as 500%.

To avoid the use of juice-strainers for the more dilute juices we are trying out pumps specially designed to handle unstrained juice. There are at least two installations of unstrained juice-pumps; one is at Ohau Sugar Company and the other at Hamakua Mill Co. These pumps were originally designed for sewage; they will even pass a piece of rope without cutting it. At Hamakua they return the 4th mill juice with one end of the pump and the 3rd mill juice with the other. They have an ordinary mill screen for the mixed juice.

Mr. Camp:

One of the points about mills that has come to my attention is the location of the horizontal bolts in certain type of housings. It is not uncommon to find the horizontal bolts extending along the exposed surface of the housing, forming pockets for the collection of bagacillo that it is almost impossible to cleam out. I have used steam jets but without success. Housings and turnbeams should be so designed as to eliminate, insofar as possible, the depositing of bagacillo.

THE MILLING OF BADILA CANE

Mr. Ramos:

I have been trying Badila cane in the field and it looks like a cane of great promise for various reasons. This cane is a very good determinator; it does not go much to mosaic and it stands drought well. I understand that in Australia it has 18% to 20% sucrose the juice being 95% purity and the fibre only 9%, also that they get 60 to 80 long tons of cane per acre (177,000 to 236,000 arrobas per caballeria. I think that I am correct in stating that the yield from this cane averages 1½ to 2 lbs. more per 100 lbs. of cane than our standard cane. This, of course, makes

it very important to know whether this cane can be ground with our equipment. I have repeatedly tried to grind my Badila cane, but without much success. I loaded a carload and placed it in a train between cars of our regular cane, and to my surprise I found that the crusher would not take it. Other cane was being ground without any difficulty, but the moment this cane come in contact with the crushers they began to choke and would only take about one-quarter as much can as usual.

Mr. E. W. Kopke:-

In grinding Badila cane in the Philippines, in order to maintai na satisfactory milling rate it has been found necessary to adopt substantially coarser grooving with cross grooves in the crusher and first two mill rolls.

Mr. Clayton:

When handling a large proportion of finely shredded Badila cane, at a crushing rate of approximately 10 long tons per foot of roll and under heavy maceration conditions, we have found it impracticable to get the rolls to take the feed at the uniform rate necessary for good extraction unless we use pushers. A pusher may be applied to any mill of a tandem. It consists of a thick blade which is the full length of the mill-roller and 4" to 6" thick at the leading edge. It slides between guides secured to the mill cheeks. The leading edge of the blade is directed at the wedge of bagasse entering the space between the front and top rolls and is forced in and out by a system of shafts and levers operated by rope drive from the mill engine. All parts of a pusher are of substantial construction. In addition to ensuring a uniform feed to the mill a pusher also expresses a good deal of the contained fluid before the bagasse enters between the mill rollers.

SECTION VI

BOILER PLANT

Types of Boilers and Furnaces.
Recovery of Heat from Flue Gases.
Economizers.
Bagasse Driers.
Extra Fuel.
Boiler Feed Water.
Boiler Inspection.
Instruments.

SECTION VI

Part 2. BOILER - PLANT.

TYPES OF BOILERS AND FURNACES

Mr. Connon:

In most of the larger factories here in Cuba recent installations of boilers have been mostly of the water-tube type. There have been some firetube boilers installed recently, but not many; impurities from the water are liable to settle to the bottom and cause the sheets to bag. In large factories the installation of fire-tube boilers necessitates the use of a great many units, as these boilers are so small. Most of the water-tube boilers recently installed have been 600 H. P. or larger; the

largest I know of are 1200 H. P. The greater number are of the straight-tube types, such as Babcock & Wilcox, Edge-Moor, or cross-drum.

Mr. McAllep:

In Hawaii boilers are divided about half and half between water-tube (mostly Stirling) and return-tubular. It is found difficult to get sufficient furnace capacity under large water-tube boilers.

Mr. Kerr:

The fuel-efficiency of water-tube and tubular boilers is about the same. In the company that I am connected with we have a great many of both kinds, and for a long time our lowest fuel consumptions were at factories that had tubular boilers. The advantages of one type as compared with the other, that is, as regards upkeep and ability to carry overload, hold in the sugar industry as every-where else. Water-tube boilers can be forced to greater overloads without loss in efficiency than can return-tubular boilers. This means that the total amount of heating surface for the water-tube boiler plant can be less than for tubular boilers.

Mr. Connon:

One great advantage of the water-tube boiler is that it can be forced to very high capacity. For power-plant work now ratings of 500% to 600% of normal rating are not uncommon and it is expected that even higher capacities will be common in the next year or two. Of course, we cannot get anything like that with bagasse at present, but the tendency is in that direction. There is one factory here that is running its boilers between 150% and 175% of rating.

Mr. McAllep:

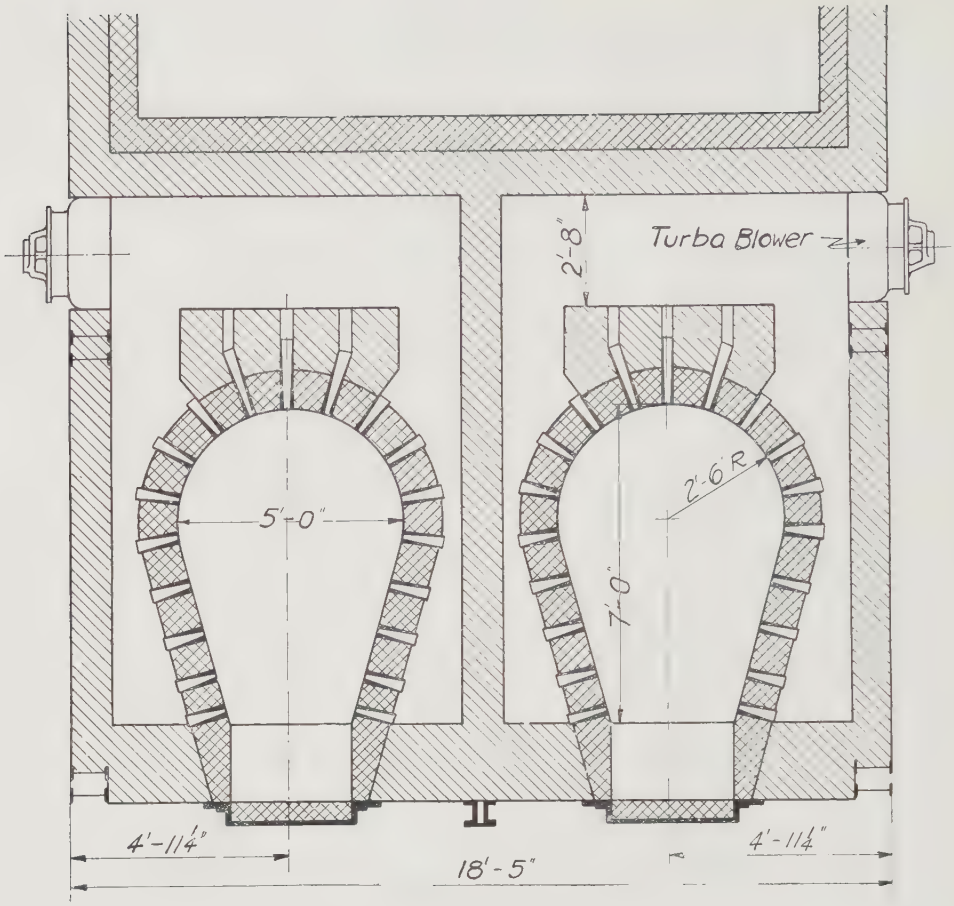
I would like to ask if they have any trouble in getting enough furnace capacity under water-tube boilers or in getting them up to a good rating, particularly with "Hearth" furnaces.

Mr. Connon:

With a large Cook ("hearth") furnace we can develop 1400 H. P. but for boilers over 600 H. P. we usually put in two furnaces, so that we can force the boilers to overloads. Rio Cauto has Stirling boilers of 820 H. P. each. With one hearth furnace under each boiler they developed 160% of rating. Last year they installed double furnaces so as to get still greater capacity. Another advantage of the double furnace is that while cleaning you do not have to shut down the whols capacity of the boiler.

The general scheme of the "hearth" furnace is shown in Figs. 1 and 2, which illustrate a double furnace of the largest size. Each half of this furnace will develop 1200 to 1400 H. P., or a total of 2400 to 2800 for the double furnace illustrated. There is no grate, the air being supplied by forced draft through tuyeres placed in the walls of the fire-pot. The bagasse is heaped up in the furnace so as to cover most of the tuyeres. The bagasse feed is sometimes thrugh the front wall as shown, but more usually through the roof directly above the firepot. Wood can also be burned in the same furnace.

One great advantage over the grate furnace is that cleaning is not required oftener than every 24 to 48 hours. The horseshoe shape is chosen in order to facilitate cleaning. The control of combustion is also easier than in a flat-grate furnace; with a steady load we can easily obtain 12% CO_2.

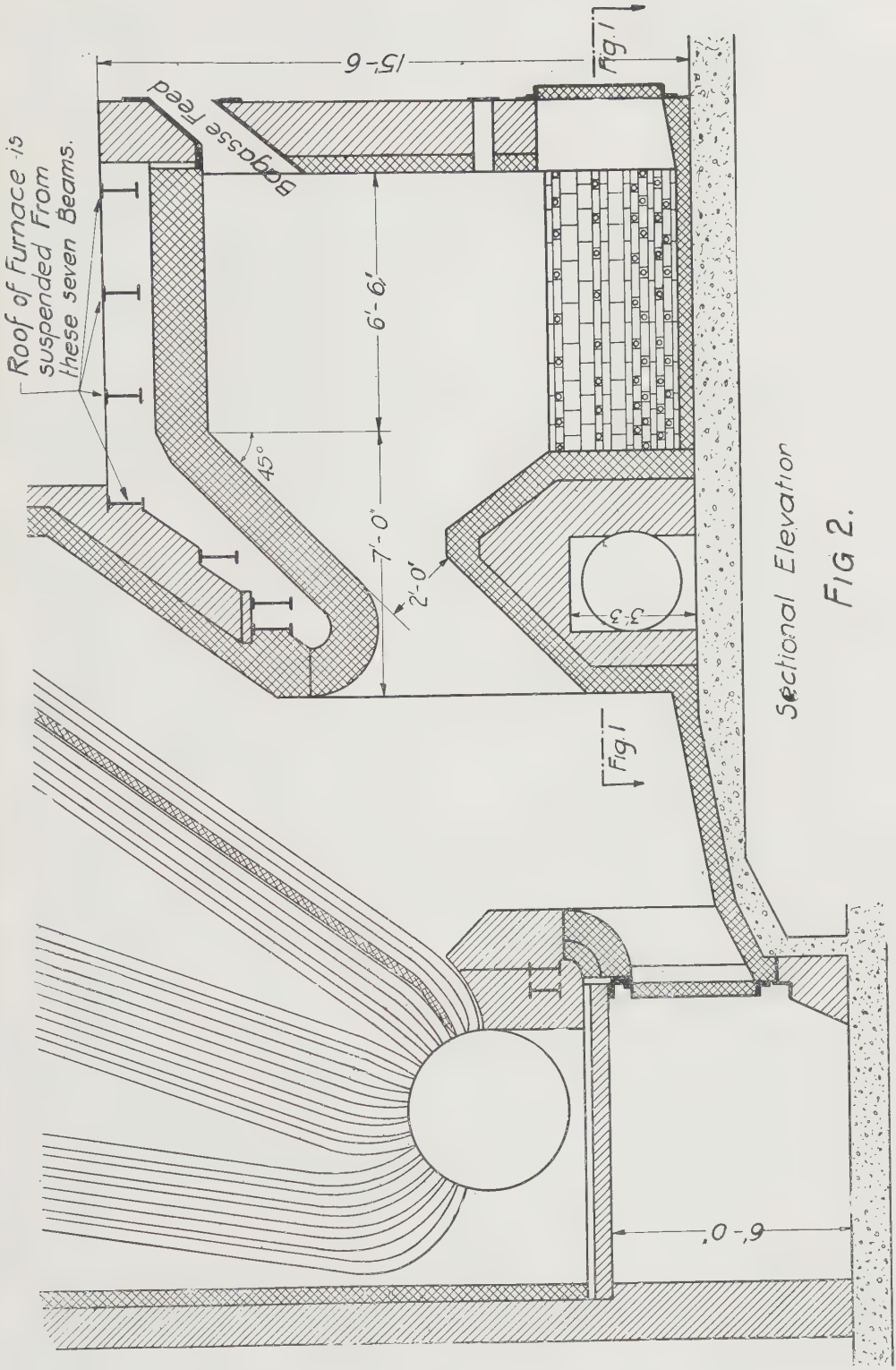


Sectional Plan

FIG 1.

Mr. Kerr:

Cuba has made some improvements in boiler-plants in the last two or three years, especially in furnaces. We have come to that in an endeavor to reduce the cost of upkeep as well as to increase economy. Many furnaces have been built in the last few years with suspended roofs, the so-called "flat-arch" construction. In Cuba we have both flat-grate furnaces and hearth furnaces, and there seems to be little difference as far as fuel economy is concerned, if well proportioned. A flat-grate furnace, if it does not have too much grate surface, thereby permitting too much excess air, can give excellent results. We are inclined to favor the "hearth" furnace, because of its rugged construction and because it can be arranged so that it is impossible to have too much excess air. In other words, by stopping up the tuyeres in the furnace or opening more of them we can fix the proper amount of air, and thus obtain fair results in spite of inattention and incompetency on the part of the operators. It is easy enough to go into a boiler room and see what the trouble is, but we have found it much harder to have the necessary measures taken for good operating; in other words, to overcome the indifference or prejudice of the men who actually run the boiler roon. We find it hard to overcome the old ideas and habits



Sectional Elevation

FIG 2.

in such things, and I imagine we suffer from that more than in other countries, on account of the class of labor that we have. Nevertheless, we are making progress in Cuba in cutting down fuel consumption from year to year, all over the Island. This year a large proportion of the factories are using practically no extra fuel.

Mr. Clayton (*C. S. R. Co. Australia*):

In our Australian mills most of the boilers are multi-tubular, whilst in Fiji the loco. type predominates. The former are always erected in a continuous setting, all cleaning of furnaces and flues being done from the front and back ends.

For burning bagasse only, the solid hearth furnace fitted with a "pyramid" grate is favored. The grate is of the stepped type made in the shape of a half cone, the bagasse dropping on the apex and being evenly distributed over the surface. For a wood and bagasse furnace flat grate bars are substituted for the solid hearth and the pyramid is omitted.

Our loco. type boilers are really coal-burning units and are used for this purpose at mills using coal for their supplementary fuel. When employed as bagasse boilers separate furnaces with solid hearths and pyramid grates are erected in front of the steel fire-box.

Some medium sized water-tube boilers have recently been installed but have not yet been put into rgular work.

At one period the discharge of charred bagasse from the chimney created a considerable nuisance; this has been largely overcome by increasing the dimensions of the furnaces at the same time improving the design. I believe our mills have as great a volume of furnace plus combustion-chamber, per unit of bagasse burned, as others have. The moisture of the bagasse entering the furnace is about 30%.

Induced draft fans and comparatively short chimneys are in general use at our mills though some factories still rely on chimney draft only. The use of short chimneys is not altogether on account of liability to damage from cyclones though this is an important consideration in some districts.

We do not get high ratings out of our fire tube boilers; they do not lend themselves to forcing.

Dr. Van Harreveld:

In Java our furnaces are nearly all of the same type having a grate of rather steep incline. The bagasse is fed by hand, with care to admit as little air as possible through the feed-openings. In the last few years we have tried to make larger furnaces with more combustion-space and with extra air admitted above the fire. We believe that the principal factor in good combustion is the man who handles the furnaces. Many factories use automatic gas-analysers for CO2 and Co. and find them very useful in showing the best method of handling the furnaces. In Java you do not often see badly smoking chimneys.

RECOVERY OF HEAT FROM FLUE GASES

Mr. Connon:

Three methods of recovering the heat wasted in the flue-gases have been tried: first, economizers to heat the boiler-feed water; second, bagasse-dryers; third, air-proheaters to heat the air for the furnaces. Of these the latest and most promising is the air preheater. When you go to "Central Cuba" you will see one of then in operation, of the "rotating regenerative" type; this form is the invention of a Swedish engineer named Ljungstrom, who developed the steam-turbine locomotive. The

air going to the furnace is heated to about 350° F. by means of the flue-gases, which are thereby cooled to 250° or 300° F. A great many of this type are in use in Europe and the Uniter States in large power-plants. In sugar factories, on bagasse-boilers, several of these have been installed in South Africa and Mexico, and one in Peru; they are giving very good results. At Central "Cuba" we estimate that the saving

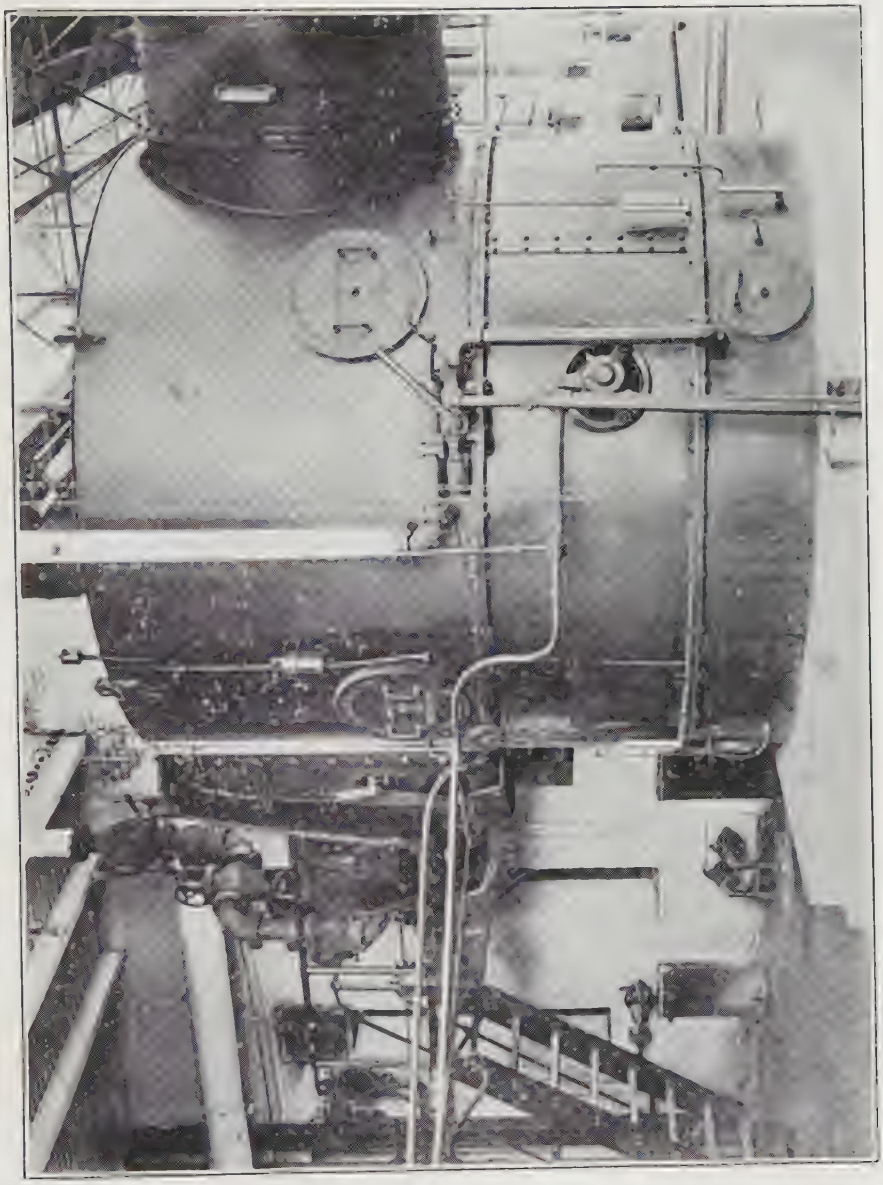


FIG. 29

Ljungstrom Air Preheater at "Central Cuba"

in fuel is about 15%, and in South Africa a saving of over 20% has been obtained. The principal cause of this saving is the recovery of 200° or 250° of heat from the flue-gases, but the increased furnace-temperature also contributes largely to the saving. The increased furnace-temperature is due partly to the actual heat contained in the preheated air, and partly to the improved combustion caused by the quicker

drying of the bagasse when the heated air strikes it. The latter effect is especially noticeable with bagasse of over 50% moisture, which with cold air burns very sluggishly. These improvements in the conditions of combustion enable a decrease in the amount of excess air required. This Ljungstrom type of air preheater is usually easy to apply to an existing boiler-plant because it is an entirely independent self-contained unit. It is housed in a vertical cylindrical casing of steel, the height and diameter being about equal. It consists of three super-imposed sections; the middle section contains the rotating heating element, the upper and lower sections being merely distributing chambers. This rotor is closely filled with crimped steel plates forming a solid mass of small vertical passages. The apparatus contains partitions so arranged that the flue-gases pass up through one side of the roter while the cold air passes down through the other side. The rotor revolves slowly so that the mass of crimped plates passes slowly through the upward current of hot flue-gases, being thereby heated, then revolves into the other side of the casing and transfers its heat to the current of air going to the furnaces. The heat does not have to pass through metal walls as is the case in the other types of air heater; therefore, fouling of the surfaces by soot does not impair the work of the apparatus, for the heat is simply absorbed from the flue gasses and given out to the air by the soot itsel. However, a soot-blower is provided, to keep the rotor clean.

The upper section contain two fans or blowers, one to force the cold air through the apparatus, the other to draw the flue gases through. These two fans are of the disk type, and are mounted on a common shaft which is driven by a turbine or motor located outside of the casing. On installing the machine the angles of the fan-blades are set so as to obtain a proper proportion between the amount of air and the amount of flue gas handled; this proportion then remains approximately constant at all speeds. The turbine or motor is usually controlled by some sort of regulating mechanism operated by the rise and fall of steam pressure; in this way the respective amounts of flue gas and of air are increased and decreased proportionately and simultaneously in accordance with the requirements of the load.

In the illustration the large pipe at the right carries the cooled flue gas to the stack. Air is drawn in at the left, around the turbine, and from the upper chamber passes down through the apparatus to a duct under the floor.

The capacity of a boiler-plant is appreciably increased by the installatoin of a Ljungstrom air preheater. First, in common with the other types, the increased furnace-temperature causes a greater heat-transmission per unit of boiler-surface; second, in this type the induced-draft fan which is part of the installation will give any reasonable boiler-overload that the furnaces, assisted by the forced-draft fan will supply.

There has also been developed an air heater, of tubular type, made up of tubes 1½″ in diameter and about twenty feet long. The air passes through the tubes and the flue-gases between them. There is also on the market a plate type of air heater in the form of a large box containing a series of plates about 1¼″ apart; the air for the furnace flows down between each alternate pair of plates and the flue gases pass at right angles between the intervening pairs. In both of these types the heat has to pass through metal walls; the heat-transmission, therefore, is rapidily reduced if the surfaces are not kept well cleaned.

Mr. Kerr:

In sugar factories this question of preheating air will need a good deal of trying out. The Cook furnace was originally operated with hot air blast. We still have, in our factories, several of these Cook furnaces with heaters in the flue, but many have been taken out. I have never understood fully why they were taken out; they were very old and probably corroded. They detract somewhat from the simplicity of the plant and since our flue-temperatures are lower than in large power-plants there is not so much saving to be obtained.

Mr. Connon:

We estimate that the Preheater at Central Cuba saves about 50 tons of bagasse per day. A ton of bagasse at the present price of fuel-oil is worth about $2.40, so this preheater gives a saving of $120.00 a day.

In a sugar factory that has to use extra fuel, the Air Preheater will show good results regardless of what may be the design of the factory. In a steam-driven factory (i. e., not electrified) it is usually impossible by ordinary methods to eliminate the consumption of extra fuel if a reasonable amount of maceration water be used. If highly efficient evaporating schemes are used, reducing the consumption of exhaust steam, the result is a surplus of exhaust, which then has to be blown off and wasted. It is only in electric-driven factories with economical generating units that the more efficient evaporating systems can be used and the consumption of extra fuel eliminated. First-cell vapor heating is about the limit for the usual steam driven factory. In such a factory, therefore, economy of fuel must proceed from the efficient production of steam rather than from its efficient utilization. This is why the air preheater is so well adapted to steam-driven factories. Of course, when the time comes that we can sell bagasse in large quantities to the fibre-board manufacturers or the chemical industries, then the utmost in fuel economy will be justifiable, and air preheaters and other fuel saving devices can be applied in any sugar factory.

Mr. McAllep:

Mr. Chairman, I do not know whether it comes under that heading, but when you come to consider our flue gases we have a good many heat units to play with. I doubt if we get much more than fifty per cent combined boiler and furnace efficiency, particularly where the moisture in bagasse is 48% to 50% as in Cuba. Of course, in Hawaii, where the moisture averages forty per cent to forty-one per cent higher efficiencies are obtainable.

I think that we get high operating efficiency as compared with plants using other kinds of fuel.

I mean probably 40% to 50% of the heat units in the bagasse go up the stack, and if we can utilize that heat by any process, we have room for great economy. That is exactly what Mr. Connon is doing by preheating.

Mr. Kerr:

It is very difficult to determine just how to compare the efficiency of a boiler plant that uses a fuel with as much moisture in it as has bagasse, with a plant that uses ordinary fuels like coal and oil, which have little moisture. The steam formed from the moisture and from combustion of hydrogen carries much heat away through the chimeney, in other words, this unavoidable loss causes a correspondingly low available heat per unit of heat evolved by combustion. On the basis of heat actual-

ly utilized per unit of heat available, I feel sure that many of our bagasse furnaces are as efficient as some of the best of those using coal and oil. We have good furnaces, we have little leakage of air and we get the excess air down to as low a point as is possible with any other fuel, we have negligible CO loss, also we can do away with radiation, as we are actually doing through the use of thick walls and insulation. To arrive at such a figure of comparison (I call it "efficiency ratio") subtract, from the calorimeter heat value of the dry substance, the heat that is required to convert the total moisture in the prdoucts of combustion of the bagasse (i. e., the free moisture in the bagasse plus the moisture due to the combustion of hydrogen plus the H2O chemically combined in the fibre and in the sugar) to steam at chimney temperature, then divide by the heat actually delivered to the water and steam in the boiler. The results obtained in this way will be a little high, perhaps 2% or 3%, but are more serviceable for purposes of comparison than the relatively lower efficiencies obtained through the use of the A. S. M. E. Code without modification. Efficiency ratios of 70% to 80% have been obtained frequently in tests made during recent years.

Phillips.

(Written). In ordinary bagasse burning boiler plants, with bagasse of 49% moisture, 2.45 lbs. of evaporation "from and at 212° F." per pound of bagasse is considered good work; that is to say, 2375 B. T. U. is obtained in steam per pound of bagasse burned.

The gross heat value of the dry matter in bagasse is about 8360 B. T. U. per pound. Our bagasse of 49% moisture, therefore, has a gross heat value of 51% of this, or 4264 B. T. U., and the gross efficiency of furnace and boiler is 56%; this is probably the figure Mr. McAllep is thinking of.

The usual formula for the net heat value of bagasse is 8360 minus 96 times the percentage of water; this assumes the free moisture to enter cold and leave at about 500° F. On this basis the heat value of the bagasse is 3648 B. T. U., and the efficiency of furnace and boiler consequently may be considered as 65%.

By Prof. Kerr's method, we correct for the combined H2O and the water of combustion as well as for the free moisture. For bagasse of 49% moisture the sum of these two will ordinarily be 30%. The net heat value, therefore, will be 3273 B. T. U., and the "efficiency-ratio" of furnace and boiler will be 72½%.

This "efficiency ratio" of Prof. Kerr's certainly seems the most rational basis for comparing furnace efficiencies, as well as for showing the effect of varying the moisture in the bagasse. However, since it regards as "unavoidable loss" all the heat that is carried away by the total moisture in the flue gases, it does not show the full increase in efficiency that is actually obtained by reduction of final stack-temperature. A "net fuel value" obtained by considering the total moisture as if it were discharged at some fixed temperature (preferably near the stack temperature obtainable by air heaters or economizers, say 250° or even 200° F.) instead of at the particular stack-temperature obtained in each different case, would more truly show the actual gain by cooling the flue gases, whether that cooling be obtained by keeping the boiler tubes clean or by some special device such as an economizer or an air heater.

ECONOMIZERS

Mr. Clayton (C. S. R. Co. Aus.):

Economizers are standard equipment at our mills; we started a long while ago with small installations and have gradually increased these where the layout is convenient. For our conditions the use of economizers is certainly justified. The ratio of boiler heating-surface to economizer heating-surface, would be about 4 : 1. So far we have had no experience with air heaters, but we are now installing one at a refinery.

Mr. Connon:

I do not consider an economizer a paying investment in a well-designed sugar factory. A properly designed system of handling the condensed water from the evaporators and other apparatus will give an ample supply of boiler-feed water at about 212° F. In fact, factories having high-effciency evaporating systems can obtain feed-water at 220°, and with high-pressure pre-evaporators even up to 235°. In order to hold the water at those temperatures we use a closed tank at exhaust-steam pressure. Thus with flue-gases at 450° or 500° there is not enough difference of temperature to justify the investment in an economizer, for it is quite an expensive apparatus. Moreover, economizers need a great deal of care.

BAGASSE DRIERS

Mr. Connon:

The moisture content to which bagasse can be dried is probably limited by its resultant physical characteristics. In Mauritius they tried bagasse dryers a number of years ago, and they found that the moisture was brought down to 35% a great deal of bagasse became so light that it was caught in the currents of gas and went up the chimney. With very fine grinding such as we have to-day, that loss would probably be very much greater, and I doubt if we could dry safely below 38%. In Hawaii, where you average 42%, to dry that down to 38% would not be worth while. To dry from 49% moisture to 38% only improves the fuel value of the total bagasse by 6%. The total increase in steam produced would probably be more than 6%, because the dry bagasse would give a higher furnace temperature and, therefore, a higher boiler efficiency, but at the best, I do not think that we could expect to get more than 10% improvement. The air preheater will extract about 70% of the total sensible heat in the flue gases above atmosphere (neglecting latent heat of the vapor-content) and if it does that it seems to me the best means to-day of reducing the chimney loss.

EXTRA FUEL

Dr. Van Harreveld:

Even though the factories make white sugar, they usually burn extra fuel equivalent to not more than 10% of the calorific value of the bagasse. The fibre in cane is about 12½%, and the moisture in bagasse about 43½%. (*) Formerly

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(*) *Note:* Therefore the total bagasse has 30½% more total calorific value than in Cuba, where the fibre averages 10½% and the moisture 49%.—*Sec'y.*

this extra fuel was mostly firewood, but during the war firewood became very expensive. Now we use mostly dry cane leaves; in 1925 the total fuel was 300,000 long tons of cane leaves, 50,000 tons of firewood and 40,000 tons of molasses. The cane leaves are very light and take a great deal of labor to load and handle, but labor costs only 20 cent U. S. per day, so that the leaves cost only about 65 cent to 80 cent U. S. per ton delivered at the factory. Some of the mills cut up the leaves and mix them with the bagasse; others burn them alone in special furnaces.

Recently molasses has been worth a higher price, for export to Europe, but some factories still burn it. The usual method is to mix it uniformly with the bagasse. It is distributed in fine drops on the bagasse just as it leaves the last mill, by a perforated pipe. If the molasses is very thick, it has to be heated to make it spray properly. It is necessary that the bagasse be fine, and that the molasses be thoroughly absorbed by the bagasse before reaching the furnaces, for otherwise there is trouble with slag. The falling of the bagasse from one carrier to another helps to mix it. If thoroughly mixed, the molasses cannot be seen as such; it merely imparts a brown tint to the entire bagasse. The bagasse will not absorb much more than the daily production of molasses; if we try to burn more than this we have trouble with slag in the furnaces.

Mr. Kerr:

We found we coul dburn molasses very successfully in oil-burners, atomizing it with high-pressure air. However, so much slag formed in the furnace and behind the bridge-wall that we discontinued this.

Mr. McAllep:

In Hawaii some factories that are not equipped to ship molasses, or not suitably located, burn molasses during the dead season. The furnaces are designed primarily to recover the potash from the molasses, the production of steam to run machine shops, etc. being considered secondary. The combustion chambers are large. In some cases atomizers are used; in others the molasses is allowed to drop on a hearth where it carbonizes and burns. The furnace efficiency is low but very little potash is lost.

Superheat and Steam Pressures.

Mr. Connon:

Quite a number of factories here in Cuba use super-heaters with the boilers, usually obtaining a superheat of 75° to 125° F. Under usual conditions, if the steam has 90° F. superheat remaining when it reaches the turbine or engines, the exhaust will be exactly dry. Thus windage-friction in the turbine is reduced sufficiently to give the turbines about 5% better water-rate, that is, they require 5% less steam. The wear of the turbine-blades is also greatly reduced.

Another advantage of superheat is that there is no condensation in the steam-pipes, hence no loss of hot water in drips. The danger of "slugs" of water reaching the engines or the turbines is also avoided.

The highest pressure regularly carried in Cuba is 160 lb.

Mr. Van Harreveld:

A few factories in Java use superheat. Most of the factories carry steam at eight atmospheres, that is, abour 120 lb. The two newest factories are now built for 14 atmospheres (about 210 pounds); they have turbines for the electrically driven mills.

Mr. Clayton:

None of the Company's mills in Australia are using superheat at the present time. It was tried some years ago at one factory for a short time, but the superheater has now been dismantled.

Boiler-Feed Water

Mr. Lanier: (Cuba)

In three factories that have come under my supervision, I have tried to obtain a slightly alkaline water for boiler feed instead of making that water alkaline by adding chemicals. We ran our juice about 7.6 to 8.2 pH and we did not have to make our return waters alkaline with other chemicals and our boilers are kept very sweet and clean. We have not had to change our boiler tubes by reason of attack from acid. At Centrals "San Isidro", "Santa Rosa" and "San Cristobal" of the General Sugar Company, we found that the pH of the return water ran between 7.7 and 8.0 during the course of the past season. We have had very successful results not only in fabrication, due to careful pH control, but in the control of the boiler food water as well. In Cuba we use as a rule cooling towers and I find that the pH of our cooling tower or condensing water, also runs slightly alkaline, unless we get an excess of sugar from entrainment. I have noticed, however, that the acidities caused by the occasional "shot of sugar" have been neutralized in time by the continual injection of alkaline water from condensate referred to above.

M. Kerr: (Cuba).

We have had some difficulty with corrosion which we suppose is due to acidity. We have been greatly increasing the capacity of our factories and this has probably increased the amount of entrainment. We take the condensate from the second, third and fourth clls for make-up feed water, for the boilers. I suppose everyone has had the experience of gettin what we call a "shot of sugar" occasionally from some broken tube-sheet, or, for that matter, from leaky evaporator tubes, and getting large amounts of sugar in the boilers. It is difficult, of course, to get this water out right away and in some cases we have had serious corrosion, so as a safety appliance, we decided to put in equipment at each factory for pumping lime or soda solution into the boilers particularly in case of one of these accidents. This is really in the experimental stage as far as we are concerned. There is, of course, danger of scaling boilers if you get too much lime. I am very much interested in Mr. Lanier's method of controlling it in the juice. We think that we have been able to control the trouble in some of the places by the method that I have mentioned.

Mr. Lanier: (Cuba).

In answer to Prof. Kerr's remarks about "shots of sugar", we all realize that the action of heat on sugar compounds in the boilers will produce acids, but if your defecation is such that you get slightly alkaline water from your return water, it is more than enough to render that acid neutral. I have recently installed this definite pH in the laboratory of those particular factories to which I had reference. We have had inspectors of boilers come around and they have found our boilers in absolutely good condition, cannot find any trouble whatsoever, which as a rule would be dangerous, on account of the corrosion in the tubes.

Mr. Cannon: (Cuba).

The tendency here in Cuba during the last few years has been to make the shut-down periods for cleaning the apparatus as short as possible. This makes it

necessary to use very large quantities of acid for boiling out. Some of this acid no doubt entrains and passes through the condensate pipes and in this may gets into the boilers and causes pitting. This I believe is one reason why we are now having *more trouble with our boilers than we did* a few years ago.

Boiler Inspection

Mr. Connon:

In Cuba there is no compulsory boiler inspection, but most of the better and larger companies insure their boilers, and the insurance companies make a yearly inspection, making recommendations for repairs and changes and then another inspection to see whether the recommndations have been carried out. This insurance here is an excellent thing, if only for the inspection of the boilers.

Mr. McAllep:

The Hawaiian Sugar Planters Association carry on boiler inspection; the insurance companies would not furnish the inspection.

Instruments.

Mr. Cannon:

In the last few years the better operated factories have been using instruments (flow-meters; CO_2 meters, etc.) to control the furnace and boiler work. These have been a great help in obtaining good fuel economy.

Mr. McAllep:

In Hawaii also we are using a number of CO2 recorders, steamflow meters, automatic foiler-feed regulators, etc.

Part. 3. CLARIFICATION.

Work on Clarification in Hawaii. *By W. R. McAllep.*
Investigations of the Bureau of Chemistry, Washington, D. C. *By H. S. Paine*
Philippine Islands. *By E. W. Kopke.*
Ash in Raw Sugars. *By F. W. Zerban.*
The Use of Hydrogen-ion Indicators for Control in Clarification.

By R. G. Padhye.

SECTION VI

CLARIFICATION

Mr. W. R. McAllep:

As an introduction to the subject of clarification, I have been requested to give a summary of the work that has been done at the Hawaiian Sugar Planters Association Experiment Station on this subject.

Our investigation of clarification was undertaken some six or seven years ago. The greatest diversity of opinion existed among factory operators as to how clarification should be conducted and what results would be secured when it was conducted at diferent reactions. Our purpose was to obtain definite information on this question that could be applied in factory practice.

The method employed was to make a clarification series on each sample of juice. Mixed juice as it came from the mills was divided into seven or eight portions. One was analized without any treatment; a second was filtered with Filter-

Cel to determine the effect of coarsely dispersed matter on the purity. (We have termed the increase in purity thus indicated the "mechanical purity increase".) The remaining portions were limed with regularly increasing quantities of lime, the object being to cover the range between slight acidity to litmus and moderate alkalinity to phenolphthalein. The limed portions were then brought to boiling and analized. As the analyses had to be made with the greatest care the portion used for the analyses was filtered, Filter-Cel being used to facilitate this filtration. Results were referred to titrations with both litmus and phenolphthalein. We were not equipped to make pH determinations until much of this original work had been done. However the neutral points to these two indicators are good reference points and enable us to translate our results into terms of pH in a reasonably satisfactory manner. At this point I might mention that in speaking of clarification reactions we refer to the reaction of the juice after it has been limed and heated. In the factory this corresponds to the juice coming from the heater.

Notwithstanding the great difference in different juices, as a result of making a great many of such tests we have been able to draw the following general deductions, on the trend of the various characteristics as the pH of the clarification is increased. Some of these seem to apply quite generally, others to perhaps 75% to 90% of our juices. These deductions have been drawn by averaging the results of a considerable number of experiments. Averages of different series of experiments have given remarkably similar indications.

(1) *Mechanical increase in purity;* the apparent increase in purity caused by removal of suspended matter by filtration with Filter-Cel increases from 0.3 to 1.0 as we increase th pH of the clarification.

(2) *Apparent purity;* a fairly regular increase is obtained until just on the acid side of phenolphtalein neutrality, after which there is a decrease.

(3) *Gravity purity;* (Sucrose divided by Brix) changes in a manner similar to apparent except that the maximum is reached at a slightly lower pH and the increase in slightly smaller any given reaction. There is no definite correlation between increase in purity and the purity of the original juice.

(4) *Glucose*; a slight increase is noticed at low pH values changing to a decrease at 7.2 or 7.3 pH. (Note that the time required for heating varied from 10 to 15 minutes).

(5) *Lime salts;* at first sometimes an increase is noticed and sometimes a decrease, but on the average there is not much change until about 7.2 or 7.3 pH; then a moderate increase occurs up to about 8.3, after which the increase is rapid.

(6) *Volume of settlings;* becomes greater as the pH increases, except as noted under item (7).

(7) *Clearness of settled juice;* improves as pH increases, nearly up to phenolphthalein neutrality. Some juices again cloud up above 8.5 or 9.0 pH; when this happens the volume of settlings usually decreases.

On the basis of these conclusions the H. S. P. A. Experiment Station advises liming to between 8.0 and 8.3 pH. In practice this cannot be done at all times because the filter presses cannot handle the increased volume of settlings. However, there has been an increase in the amount of lime used in Hawaiian factories since this investigation was undertaken, and this has been accompaneid by improvements in recovery. These improvements have been due as much to the reduction in inversion losses as to the better increse in purity.

In the course of this work Mr. Bamanti demonstrated that the phosphoric acid content of a juice is the major factor determining how clear a clarified juice can be secured. It is immamterial whether the P_2O_2 occurs naturally in the juice or is added. Naturally the amount of material causing turbidity in a juice is a complementary factor. We have studied this factor, preferring to wait until Dr. Paine and his coworkers in Washington have fully developed this technique. However, we have never encountered a juice low in phosphoric acid that would yield a clear juice with lime alone, nor have we ever found a juice high in P2O5 from which a clear settled juice could not be obtained.

Another subject in our clarification program is the study of inversion. Published scientific work does not deal with the pH range with which we are concerned in cane sugar factory operation. A large amount of work has been done on this subject at the H. S. P. A. Experiment Station and a progress report has been published but the work is not yet completed. Two major factors complicate the study of this subject; increase in ionization, or as we have termed it "development of acidity", and the comparatively large factor of error in available analytical methods, which renders it extremely difficult to measure the small changes that must be determined if inversion at low velocities is to be defined.

It is difficult to express our results in a discussion such as this. Increase in ionization accompanies inversion both in juices and in pure sucrose solution. We have some data indicating that the limiting value is in the neighborhood of, certainly not much below, 3.5 pH. The velocity varies greatly in different juices. In the same juice the velocity increases as pH decreases. The velocity increases rapidly as temperatures increase, following a very similar law to the increase in inversion velocity with increase in temperature.

I believe it best to think of inversion taking place at all pH values but becoming infinitely slow as pH increases and temperature decreases. We find more than a negligible inversion velocity at temperatures closely approaching th boiling point even on the alkaline side of 7.0 pH. Increase in pH is a good index of inversion velocity at any given mean pH and given temperature. According to our data inversion velocity "per unit of hydrogen Ion" (if 1 may be permitted to use this expression increases as pH increases.) Our data for change in inversion velocity in juices with change in temperature are about the same as the published data for solution of pure sugar.

Dr. H. S. Paine:

I have been asked to describe the investigations conducted bv the Bureau of Chemistry, U. S. Department of Agriculture, on the defecation of cane juice in connection with raw sugar manufacture. Perhaps this work which we are now conducting in Porto Rico will be of most interest to those present. This work may be considered under two phases.

One phase of the investigation represents an attempt to evaluate more definitely the various factors involved in the defecation of cane juice in relation to the pH to which the juice is limed. These various factors may be listed somewhat as follows: (1) the degree of total non-sugar elimination, (2) the degree of colloid elimination, (3) rate of settling of mud under standard conditions, (4) volume of mud under standard conditions, (5) clarity of decanted juice, (7) CaO content of decanted juice, (8) pH of decanted juice in relation to the possibility of inversion at later stages in the process.

These various factors are also being studied on relation to the P_2O_5 content of the juice and its content of collodial material. The ultimate purpose is to ascertain the optimum pH to which different types of juice should be limed in order to obtain the best net result from the point of view of the various factors above outlined. In carrying out this in vestigation, various lots of juice representing typically different conditions such as immature cane, deteriorated burnt cane, varieties of cane such as Uba, etc., are limed to different pH values, such as 7.0, 7.5, 8.0, and measurment is made of the total non-sugar elimination, colloid elimination, rate of settling of mud, volume of mud, clarity and color of decanted juice, CaO in juice, etc., in each case.

Total non-sugar elimination is determined by weight, by filtering a representative sample of the defecated juice by means of ignited and washed Filter-Cel and drying and weighing the residue, making suitable correction for the weight of Filter-Cel added. An ash determination is also made and the organic non-sugar elimination is determined by difference. The degree of colloid elimination is measured by means of the dye test which will later be described at this meeting, and also by the use of standard ultrafilters. The rate of settling and volume of mud under standard conditions is measured by means of jacketed Pyrex glass defactors, steam being passed through the jacket and close control of temperature being maintained.

In the case of "refractory" juices, particular attention is given to the character, as well as the quantity, of colloids present in the juice. This has relation particularly to the proportion of what we term "reversible" and "irreversible" colloids. These terms may be explained by stating that the reversible colloids of cane juice are of the particularly gummy type, are relatively low in ash content, and upon being dried readily redissolve or redisperse in water. Irreversible colloids, on the other hand, after being once flocculated or dried do not readily redissolve or redisperse in water. They have a relatively high ash content. It has been found that the colloids eliminated by lime defecation of cane juice are almost exclusively of the irreversible type. The though suggests itself, therefore, that in the case of refractory juices, in addition to possible deficiency of P2O5, there may possibly be a greater proportion of reversible colloids present than in more normal juices.

The second phase of our work which is now being conducted in Porto Rico relates to the possibility of automatically controlling the liming of cane juice at any definite pH value that may be desired. This investigation is being conducted at a factory where continuous liming is employed. The equipment which we are using consists essentially of a recording potentiometer that furnishes a continuous record on a chart in the same manner as a recording thermometer. The pH is measured electrometrically, a tungsten electrode being placed in the juice at a suitable point and the juice being kept well mixed by means of a stirrer at this point.

In addition to furnishing a continuos record of pH, the recording potentiometer controls a motor which in turn actuates a tilting weir box adjusted in such a way as to control the addition of lime. The control mechanism of the recording potentiometer may be set at any desired pH value within a given range, and it is the purpose of this part of the investigation to provide the necessary accesory control whereby the liming of the juice may be automatically maintained at the pH value desired.

The final result which we hope to attain in this investigation represents a combination of the results obtained from both phases as already outlined. In other words, we hope the data obtained in the first phase of this investigation will be sufficient to indicate the optimum pH to which juice for any given perior of ope-

ration should be limed in order to obtaind the net maximum results from the standpoint of the various factors considered. It is hoped that the investigation will indicate a sufficiently rapid test by which the optimum pH can be determined directly or indirectly, as the occasion arises.

The recording potentiometer would then be set to control the liming automatically at this pH value. Whenever the character of the juice varies sufficiently to justify a change in the pH to which it is limed, the setting of the recording potentiometer would be changer to this new pH value, as determined by suitable test, and this new pH value would be maintained until the juice changes again in character. In this way it would be possible to continuously approximate maximum efficiency in defecating and clarifying juice, whereas at present it is known that the character of the juice at any given factory is changing more or less during the season and that a pH value which is suitable for one type of juice gives relatively inefficient results with another type.

In other words, it seems logical that instead of the factory maintaining the same pH throughout the season in defecating juice, the pH value to which the juice is limed should be changed as required in order to adapt it to the varying characteristics of the juice. If this were done, the efficiency of defectation would be maintained at a more uniformly high level, instead of fluctuating with the character of the juice, as is now the case.

Mr. E. W. Kopke: (Philippine Islands).

Numerous improvements in filtration and clarification equipment, particularly in recent years, have resulted from a realization of the inefficiency of older types of plate-and-frame presses, intermittent settlers, re-settlers, etc. Besides the relatively high cost for labor and materials such as filter cloth, many operators are today giving closer attention to preventable heat losses. Also the advantage of minimizing the time of exposure of juices and sugar solutions to high temperatures is becoming more widely reorganized.

I wish to point out, or, rather, emphasize the inadequacy of juice clarification alone. If we dilute a first massecuite with water to the same density as that of the clarified juice, (so as to be able to measure its clarity), we will find, invariably, that there has been a very great drop in clarity due to the precipitation of various substances during evaporation in the effects and pan. I have found first massecuite whose clarity was as much as 10 millimeters "Kopke clarity" less than the clarified juice from which it was made. Obviously the clearness of the clarifield juice may be, and usually is, a poor criterion by which to judge the condition of the subsequent liquors.

Juice clarification alone is not enough as is proven by the relatively large quantity of insoluble gummy matter removed by centrifugal clarification of the molasses prior to the final boilings. The removal of these gummy impurities from the concentrated liquors improves the subsequent crystallization, the recovery and also the quality of the sugar.

I would ask Mr. McAllep if, as a result of the closer attention to the clarification methods and practice in Hawaii, there has been realized an improvement in the general boiling-house work.

(Mr. McAllep expressed the affirmative.)

Dr. H. S. Paine:

Replying to the inquiry relative to the work done by the Bureau of Chemistry, U. S. Departament of Agriculture, on the dye test, I would explain that this is a method for the approximate quantitative estimation of colloids, i. e. material present

in the colloidal condition in juice and sugar liquors. In the nature of the case, a precise determination of the colloids is extremely difficult, if not impossible, in the present state of our knowledge of the subject. However, in view of the importance of defecation and clarification in the preparation of cane juice for production of raw sugar and in the refining of same, and in view of the fact that such purification, whether effected by lime or by bone char, consists for the most part of the elimination of collodial material, it is important that methods be available for marking at least an approximate quantitative determination of the collodial material present at different stages in the process.

In applying the dye test, the basic dye Night Blue, which carries a positive electric charge in an aqueous medium, is used. The colloids present in the cane juice are negatively charged, and the principle of the method is based upon the neutralization of the negative charge on the colloid particles by the positive charge of the basic dye. An approximate quantitative measure of the colloids present is obtained by the amount of dye required to exactly neutralize the electric charge on the colloid particles.

The technic is simple and may be described as an electric titration. It is important that the juice be adjusted to a constant pH, usually 6.0, before the dye is added. A solution of the Night Blue is then added gradually until exact neutralization occurs. As a result of this neutralization of electric charges, mutual flocculation of the juice colloids and the Night Blue results.

In order to determine when the electric charges are exactly neutralized, it is necessary to use an ultramicroscope. This can be easily constructed, however, from ordinary microscope, suitable lenses, a screen with a slit, and a small arc lamp. A cataphoresis cell, consisting of a capillary glass tube with upright glass reservoirs sealed onto each end, is place on the stage of the microscope directly beneath the objective. The capillary is filed down at the portion just beneath the objective, so that two plane surfaces at right angles to each other are produced. In the position in which the apparatus is assembled, one of these surfaces is vertical and admits the focussed light from the arc lamp, while the other surface is horizontal and permits observation of the interior of the capillary tube through the microscope. The colloid particles are thus illuminated by the light from the arc lamp, and observation is made through the microscope at a right angle to the direction of the light from the arc lamp. Electrodes are located in the small, upright glass reservoirs sealed at each end of the capillary tube. A current at a voltage of abuot 220 v. may be allowed to pass between the electrodes, and the direction of the current may be reversed by means of a switch.

In operating the apparatus, the sample of cane juice, for instance, after being adjusted to a pH of 6.0, is poured into one of the reservoirs and passes into the capillary tube. When the current is allowed to pass, it is observed by looking through the ultramicroscope that the colloid particles move progressively toward the positive electrode. The sample is then withdrawn from the reservoirs and capillary tube, and a small proportion of the standard dye solution is tested again in the cataphoresis apparatus. It is now observed that, owing to partial neutralization of the negative charge of the colloid particles, they move less rapidly toward the positive electrode. More dye solution is added and the procedure is repeated until, when observed in the ultramicroscope, the colloid particles no longer move progressively toward either electrode when the current is reversed. The negative electric charge

of the colloid particles is now exactly neutralized by the positive charge of the particles of Night Blue.

What is termed the "day value" can now be calculated by dividing the weight of the dye added by the concentration of solids in the juice (or, if desired, the corrected Brix reading), and multiplying the quotient by 100,000 in order to give a whole number. The value obtained indicates relatively the approximate quantity of the colloids present. Thus, if in two cases the dye values obtained are 200 and 300, the latter indicates the presence of approximately 50% more collodial material than the former. It is assumed in making this test that the quantity of electric charge per unit of weight of collodial material is constant. This, of course, is not strictly true. However, the method has been found to yield results of considerable significance, and the data obtained have been found to give excellent correlation with other measurements and observations. The greatest degree of accuracy is probably attained where comparison is made between different samples representing the same stage of the process, such as, for instance, in the comparison of different lots of raw sugar.

Extensive data on the dye value of raw sugar have been accumulated. Carefully selected samples from shipments to refineries have been obtained in the case of some 120 raw sugar factories, 90 of which are located in Cuba. Observation of the refining of a considerable number of these lots of sugar was made in a sugar refinery for a period of about 4 months. The dye values were compared systematically with (1) small scale filtration tests which diatomaceous earth, (2) the quantity of colloids obtained by ultrafiltration, and (3) by direct observations in the refinery at each stage in the refining process. A close correlation was found between these four different procedures. In general it was observed that when the dye value was high (representing a high colloid content in the raw sugar), the small scale filtration test indicated a poor filtering sugar, high colloid contents were shown by ultrafiltration, and difficulty in refining was indicated by observation in the refinery, especially in filtration of the washed raw sugar melt and at the bone char filters. In the case of raw sugars of high colloid content, the bone char was exhausted more rapidly than usual.

In a few instances, a high dye value and a high colloid content obtained by ultrafiltration coincided with a normal filtration rate in the small scale filtration tests. In these cases it was found, however, that difficulty resulted at later stages in the refining process, particularly at the bone char filters, and in the crystallization of low-purity massecuites, indicating that the colloidal material present was unusually finely divided, so that it did not appreciably affect the rate of filtration of the washed raw sugar melt.

The dye values found in the case of the ray sugars examined from the 120 odd raw sugar factories already mentioned varied from a minimum of about 200 to a maximum of about 500. On this basis we have classified raw sugars into the grades, as follows, depending upon the dye value: (1) best grade, dye value 200-300, (2) medium grade, dye value 300-400, (3) poor grade, dye value 400-500. This classification agrees closely with direct refinery observations.

It may also be of interest to those present to know that the dye test has been used in estimating the approximate proportion of colloids removed from cane juice by defecation with lime. The percentage removed is about 20-25%. Double carbonation, on the other hand, removes as much as 65-70%. It is believed that the dye test will be of considerable value in obtaining more exact knowledge of the ef-

ficiency of defecation and clarification under different conditions, as well as the efficiency of every step in the sugar process where an attempt is made to eliminate colloidal material.

Dr. F. W. Zerban, (N. Y. Sugar Trade Laboratory, New York).

Distributed copies of a reprint of a paper on "Ash in Raw Cane Sugars and the Specific Conductance of their Solutions". This paper had been presented by him and Mr. L. Sattler at the Philadelphia meeting of the American Chemical Society, September, 1926. It was later printed in "Facts about Sugar", December 4a 1926. Those interested in the subject are referred to these sources or to Dr. Zerban for copies.

THE USE OF HYDROGEN-ION INDICATORS FOR CONTROL OF CLARIFICATION IN THE MANUFACTURE OF PLANTATION WHITE SUGAR

Submitted by R. G. Padhye, Bombay, India.

ABSTRACT

In the manufacture of plantation white sugar the clarified juice must be clear and brilliant and free from suspended matter; it also should be light in color, but clarity is more important than color. However, an alkaline clarification must be avoided, otherwise calcium glucosate is formed and at light temperature is decomposed with the formation of dark-colored compounds. Manufacturers therefore prefer to keep the clarification just a trifle on the acid side, but as near neutrality as possible so as to avoid inversion of sucrose and obtain good settlings.

Our factory has an eleven-roll mill, 30″×60″; we use cold water imbibition, (about 8% on cane), after the second mill, and return the juice of this mill to the bagasse after the first mill; we obtain 93% sucrose extraction. The mixed juice is sulphured to an acidity of between 2.8 and 3.0 c. c. of N/10 NaOH per 10 c. c. of juice (Phenolphthalein indicator). We have found that with acidity less than 2.8 we obtain a juice slightly colored and sometimes cloudy, and that with acidity more than 3.0 the precipitate is too voluminous and settles slowly. Cream of lime of 12° Beaumé is added, and the juice is sent to eliminators in which it is "cracked" and allowed to settle. The first runnings which are somewhat dirty, are passed through a bag filter, then through a 100 mesh screen, to the evaporator supply tank; the rest of the decanted juice goes direct to the same screen and tank.

The mud from the eliminators is mixed with the juice from the filter-presses, then heated and allowed to settle. The decanted juice from this is passed through a bag-filter and a 100 mesh screen to the evaporator supply tank; it usually has an acidity of 0.6 c. c. To the remaining mud a little lime is added, then it is pumped through the filter-presses. The filtered juice usually has an acidity of 0.4 c. c. to phenolphthalein, but is alkaline by pH tests, its pH being 7.5. For this reason it is returned to mix with the mud from the eliminators.

In liming the sulphured juice, each tankful is titrated to phenolphthalein, and the operator adds lime according to the table calculated to give the following end-points, which practical working of the factory has shown to be the fost desirable:

Acidity of sulphured juice. . .	3.1	3.0	2.9	2.8	2.7	2.6	2.5
Acidity of limed juice cold. . .	1.1	1.0	0.9	0.9	0.8	0.8	0.7
Acidity of clarified juice. . . .	0.8	0.8	0.7	0.7	0.6	0.6	0.6

On introducing pH control, using the La Motte comparator set, we discovered that *all of the optimum clarified juices prepared according to the above table had a pH of 6.8,* although their acidities to phenolphthalein varied from 0.8 to 0.6. This is evidently due to the "buffer" action of the calcium sulphite formed; with the greater sulphitations there is more calcium sulphite formed, which hinders the dissociation of the acid so that greater titratable acidity is required to give the same pH. The optimum results are therefore obtained by working to a fixed pH, and it is not necessary to consider the variable acidity.

We also found that the juice decanted from the mudsettlers, which had 0.6 c. c. acidity was pH 6.8. It is therefore of the correct pH to be sent to the evaporator.

An interesting point is that our labor, in Western India, is usually so ignorant that they cannot distinguish between shades of color and therefore cannot use the pH control. Even litmus, involving a distinction between red and blue ,is not found suitable to them. For this reason, phenophthalein is the indicator that has to be used by the factory operators. The pH determinations are made only by trained laboratory assistants.

Part.4. Section VI.

METHODS OF BOILING SUGAR

SECTION VI

Part 4. METHODS OF BOILING SUGAR.

Mr. McAlep of Hawwaii:

By the term BOILING SYSTEMS, I mean to include the general handling of the massecuites and molasses. That is, the system we use for getting our commercial sugar.

Mr. Tarleton of Cuba:

I am sorry that we have no more of our Fabrication talent here to-day as this meeting was not previously advertised. I understand some of the boys from the field will attend the Saturday meeting. However, I see quite a few whom we will be glad to hear from. According to the way Mr. McAllep has planned this discussion, I understand that we are to take up boiling methods (that is, handling of massecuites) and quality of sugar under the same discussion, since there is a very close relation between the two. I would like to see the subject of quality of sugar open for further discussion when we take up Clarification, since I feel that clarification has a more direct relation on the quality of sugar than any other step in the manufacture.

I might say that there have been very few changes or little progress made in the methods of boilings since I first came to Cuba some twenty years ago. The only important change made during the last few years has been the introduction of the "seed" system, which was introduced eight or ten years ago. By the seed system we mean taking the dried low-grade sugar (mingled with meladura or molasses) into the pan as a footing for first or second strikes, instead of graining in the pan. This is more or less the general custom in Cuban mills. Some mills are using seed for all their 96° sugars, only graining for low grade; however, in our Company we have had a tendency this year to use seed as little as possible, only enough to bring up

the size of the grain of the low grade, and are making most of our first and second massecuites from graining straight meladura. You will understand that in Cuba we use the words "meladura" and "syrup" interchangeably to denominate the material coming from the evaporators. We feel, after listening to criticisms of the refineries as to irregular grain size and imperfect crystals, that we can make a more uniform grain by straight boiling. Our attention was also called to the existence of what they term "Birds-eye" grain, usually found in mills whose defecation is improper. By "Birds-eye" is meant a grain with dirt enveloped therein which cannot be washed off. This was caused by dirt sticking on the grain used for seed and the grain being built up around this impure nucleus.

The general practice in Cuba is the use of the "three-massecuite" system. That it, first massecuite which is a straight syrup massecuite usually of a purity of 80 to 82, second massecuite about 70, and third massecuite as low in some cases as 53 or 54 purity (usually, however, about 58 purity).

In some of our mills we have introduced the double purging of low grades, that is, redrying of the low grade sugar before using as seed; this discussion will come up later.

Mr. McAllep:

Our boiling system in Hawaii up to about ten years ago was almost entirely the "two-massecuite" system, that is, all the shipping-sugar massecuites were reduced to the same purity, which was in the neighborhood of 73 to 75, in some cases slightly higher, giving a molasses for the low-grade work of about 55 or slightly lower. In the past seven years we have gradually increased the polarization of Hawaiian sugar from 96.5 to slightly over 97.5 and it will probably be slightly higher this year. The two-boiling system is not adapted to producing higher polarizations economically. One reason for this two-massecuite system having been adopted was in the interpretation put on the clause against "mixing sugars" in the Refiner's contracts. Another reason was the desire to ship a single grade of sugar, for under the New York schedule of "ups and downs" there is a certain polarization that brings the maximum returns per unit of sucrose in the syrup.

Boiling methods are now being modified. The first change made in many factories has been to a system where the first massecuite was straight syrup, using low grade sugar for seed. A pan was usually built up and one-third cut making a straight syrup strike; then a second cut was finished with a bit of syrup and the molasses from the first cut, making the "B" usually 76 to 78 purity; then the third cut would be finished with syrup and the molasses from the second cut. The trouble with that system was that we had two low-purity massecuites to one high. We have been working in the last few years (insofar as the equipment developed for the two-boiling systems) toward a reduction in the amount of low-purity massecuite. With high purities, two high-grade massecuites to one low-purity massecuite can be boiled, the low purity massecuites being of about the same composition that we would have had in any case in the two-boiling system.

Sugar from the low-purity massecuite requires some washing to bring it up to 97.5, because with us a sugar that is produced from 75 purity massecuite will be between 95 and 96 polarization and we are making 97.5 sugar. A couple of years ago we found that raw sugar in sugar crystalized from high-purity massecuite was of better composition than the raw sugar in sugars produced from low-purity massecuite, giving better refining qualities. We get ash crystals in our molasses which are easily recognized. There is less tendency for these crystals to concentrate in the sugar

from high-purity massecuites. Also as the pH decreases as the process proceeds, we have precipitation of extremely finely divided organic matter to which you might proprly apply the term "Colloid". This is a material factor in the quality of our sugar. For these reasons we have been working, in an experimental way at least, with double purging of low-grade sugar.

We are working for high recoveries in Hawaii and are trying to get molasses to a low point. In no case do the factories reach the limit of crystallization or even approximate it. At the Experimental Station we have taken final molasses which now averages about 37 gravity purity, concentrated it and seeded the massecuite, and reduced it to between 27 and 30 gravity purity. Our limiting factor has been the same as in the factory: viscosity. This work demonstrated that reducing the final molasses purity was a mechanical problem. Getting best grain in our low-grade massecuite and getting efficient centrifugal work has resulted in a reduction in our molasses-purity in Hawaii. Our low-grade sugar is rather low in purity; I would say our average is between 70 and 75 apparent purity. Our low-grade sugar is of a rather small grain because we have found that a rather small size, in the neighborhood of 0.2 to 0.3 mm. in length, renders it possible to arrive at a low purity without introducing false grain, and this is about the smallest grain we can separate in our centrifugals. The amount of low-grade sugar greatly exceeds the amount of seed that is required for boiling a large grain. We find that taking that low-grade material in that condition back into the shipping-sugar pans greatly reduces the filtration rate, and perhaps other refining characteristics, of our shipping-sugar, and that is the reason we have been working experimentally with double purging. It has not been adopted in practice as yet, because of limited centrifugal capacity.

Mr. Tarlton:

The three-massecuite system is used for quick elimination of molasses, trying to get molasses through the house as quickly as possible, and prevents the circulation of molasses. The crystalizer capacity in Cuba is very small. We are working in some of our mills as low as 8 cu. ft. per 100 arrobas (151 cu. ft. per T. C. H.) We have to do as much of our work as we can in the pans, and we find the three-massecuite system much faster. In order to get our molasses down, we have to get massecuites down as low as possible. We go down as low as we can, without getting a film on the third massecuites in the centrifugals, going down as low as 52 purity in some cases; general practice is about 55 to 58. The three-massecuite system aids in getting the first and second molasses purity down.

Mr. McAllep:

"Shock" seeding (taking powdered sugar into a pan) is used extensively for graining low-grade massecuites.

Mr. Chiquelin of Louisiana:

I have used even raw sugar for shocking; it is not the grain you put in, it is just syncopation of the sugar formed at a certain point of concentration. I know of a plantation in Louisiana where they made a very high grade of white sugar; the amount of sugar put in the vacuum pan of 10 ft. diameter was about three or four milkcans of powdered sugar just as the crystals are formed.

Mr. del Valle of Porto Rico:

In Porto Rico we use the three-massecuite system, taking third sugars back as you do in Cuba.

Mr. Chiquelin:

I was Superintendent of a sugar factory in Honduras and the purity of the juice never went above 70, so it was useless to try a three-massecuite system when we could do it with two.

Mr. Lanier of Cuba:

I do not fully believe in the shocking process. It has been my experience that the uniformity of the grain depends more or less on the ability of the sugar boiler operating the pan, rather than on shocking by introduction of finely powdered sugar.

Mr. Sauls of Cuba:

We use the two-massecuite system at our factory "Jatibonico", because we think it is simpler and you can do your work faster and not be bothered with making three massecuites; I have never had any trouble with it. I used the three-massecuite system for about three weeks, but it was very complicated and caused us much inconvenience, so we dropped it. Having a high juice we have no trouble to get our first massecuite down to 70 and 74, and purity of molasses from 48 to 52, depending on how much you have to wash your sugar. We control our second massecuite from the amount of grain taken into the pans, bringing the massecuite down to 56. First massecuites are 70 to 72 and often as high as 74. The purity of the first molasses comes 22 points below the purity of the first massecuite, drying it hot. About making syrup strikes at intervals, it depends upon the condition of the factory. If we are grinding burned cane we change the molasses frequently; otherwise, not so often. Sometimes we go three weeks without changing molasses. I use all straight grain, 3rd sugar which is mingled with molasses or meladura and mixed with first massecuite and dried with first sugar. What size grain do we use? We do not have much trouble with that. We make a fine hard grain, and find that after 72 hours cooling it has increased in size quite a bit. We do not have to wash the sugars a great deal and the sugar stays bright. We grain at about 23" vacuum.

Mr. Keller of Cuba:

After having worked the two-massecuite system for a good many years, I tried the three-massecuite and discarded the two-massecuite for the three. If you analyse it you will find you are putting more work on pans, crystalizers and centrifugals. using two massecuite system. Once organized, everything works apparently smoother.

Mr. McAllep:

If you are working syrups such as we have, at 86 and 87 purity, the two-massecuite system will require boiling a considerably greater amount of massecuite than the three-massecuite system. In one mill, where Mr. Smith was doing this work a couple of years ago, they were operating on two-boiling system with I think about 87 to 88 syrup purity and they were using extra fuel at that time. They immediately got away from the use of extra fuel when they went to the three-boiling system as you call it here, although modified to the extent that I have described. They got a materially larger number of high-purity strikes than they did low.

Mr. Sauls:

The average polarization of one crop at Jatibonico was 96.70, the sugar was received in New York at 96.62 polarization; the year before it was 96.85 and polarized 96.75 in New York. This year our sugar is higher, 96.90, a rise in polarization of 0.2. These are average polarizations. We usually get about 3½ to 4½ firsts to one third, but at the end of the crop as much as six to one. The purity

of the normal juice for the crop is 82.36 and for the last run was 83.40. To keep massecuite down to 75 purity is simply a question of taking back more molasses.

Mr. Keller:

At Central Stewart we had no trouble in getting molasses down with an initial purity of 86.

The relative rates of deterioration of the sugar made in these two systems are of great interest. We have always calculated that the susceptibility of deterioration is the factor of safety of 0.3 which has been changed to 0.25 and I would like to ask if this question changes now that we are making higher-test sugars? What is the tendency in Hawaii with a sugar of 97; has the factor of 0.25 increased or decreased with the polarization?

Mr. McAllep:

In the work in Hawaii by Dr. Morris and Noel Deerr, the turning point between good-keeping sugar and a sugar that would deteriorate was at a lower moisture content than 0.3 "deterioration-factor". Their work was done before what is termed "deterioration factor" was known in Hawaii. A large portion of their work was done on sugars of apparently 96° polarization. The dividing line between deteriorating and non-deteriorating sugar was 1% moisture, which corresponds to 0.25 deterioration-factor. We consider 0.25 the standard. There is no doubt but that some sugars will keep at a slightly higher water-content, but we consider 0.25 the dividing line. This refers to our tropical polarization, not to polarization at 20° for sucrose and determining moisture at 100° C. Now I would like to interject this question of polarization. I assume that your average temperature down here is not far from 26° C. and that polarizations are made at that temperature. Commercial polarizations are at 20°. In the absence of deterioration in the sugar it should show at least 0.2 higher in New York than here on this Island. The average polarization of our sugars at the refinery is at least 0.2 and probably 0.3 higher than the averages reported by the plantations.

Mr. Keller:

We find that to get moisture-content down we need mechanical dischargers as the men cannot cut any quantity of sugar and hold down the factor of safety to 0.25.

Mr. McAllep:

Sugar dried to 0.25 deterioration factor is fairly hard; it is difficult to get out of the centrifugal. Plows are used in some factories and are found an aid in getting sugar properly dried. If the men are made to stop the machine and dig a place to insert the plow, they have but little incentive to try to discharge improperly-dried sugar. The question of grain is also a factor. It is easier to dry a large grain. We have a grain control at the Experiment Station. The factories send in bi-weekly samples which are put through laboratory tests for size of grain. The sugar is sifted in a bath of sugar-saturated alcohol. Details of the method have been published in the sugar journals. This separates the grain into different sizes. Our standard is: "Never more than 25% of the sugar being less than 3/4 mm. in size".

Mr. Tarleton:

In Hawaii, is the two-massecuite system more general than the three-massecuite system?

Mr. McAllep:

It was used almost without exception, but now in most of the factories it is modified toward your three-massecuite system. There are more three-massecuite systems than two in Hawaii. This tendency shows that we prefer it. Remember that the average polarization for the crop, at the refinery, was 97.5.

Dr. Van Harreveld of Java:

If we have high purity in our massecuite, we have to boil in A, B, C, and D, to give a final molasses of low purity.

Mr. Lanier:

I find that in order to reduce purity of final molasses, I have to boil three massecuites. This results also in fuel-economy, also in better keeping-quality of sugar, because of producing better grain. I realize that when you get 80 or 82 purity juices the two-product system may be possible, but I have always experienced difficulty in lowering the final molasses by the two-product system when having initial juice purities of from 84 ta 87 and low glucose content.

Dr. Van Harreveld:

If we want to exhaust our molasses very well, we have to make our last boiling of as low a purity as possible. Our last boiling averages 56.5 final massecuite purity for all factories with a mean molasses purity of 34, poralization purity 30. We have tried to get the molasses as well exhausted as possible; therefore, we simply have two methods, either to raise the Brix of the last boiling or to lower the purity. Raising the Brix gives much trouble in the centrifugals, and only very few factories have enough capacity to do it. We do not cool very much, only 24 hours, and, therefore, have to make the last boiling as low a purity as possible. Most factories use seed. The low-grade sugar is all used as seed for raws and white sugar but just enough to get rid of it. We prefer the seed system. We use hot air to dry all the sugars. Single polarization only is made from the molasses.

Mr. Grayson of Argentina:

We are refining all our sugars for consumption in our own country. Raw sugar passes from the centrifugal machines to the melters. We have to pay a great deal of attention to color and for that reason we are trying to keep our first masseecuite to as high a purity as possible. We use the three-massecuite system using third sugar as seed for our second boiling instead of using it for first sugar. We use it for boiling-in our first molasses. We take the wash from the first strike into the first pan. We keep the purity of the first 80, the second 70, and the third 56. If we go below 56 we get trouble in the centrifugal machines with a film in the basket, and if we go higher than that we get high molasses. The low grade from the refinery is returned to the raw side and goes back into the process. We have adhered to the three-massecuite system right along, but I am going to try the two-massecuite system at the beginning of the next crop.

Our purities average about 33.5 to 35, molasses loss being around 1%. The second sugars are double-purged in order to economize in water and to keep them white enough, also to get rid of the red color due to the overheating in the pans. Our sugars are washed to 99° polarization with about one and a half gallons of water; each centrifugal has a hinged cover with a hole in the top, so that steam can be introduced into the machine at a pressure of 30 lbs. with about 40° superheat.

Mr. Bennett of Queensland:

Usual Queensland practice is to produce a high grade raw sugar from all three massecuites boiled. The average polarization of our bagged sugar is approximately 75° Pol. Some few factories return the third massecuite sugar to process as seed footing for the higher purity strikes, but the majority boil direct to grain from the "liquor" or "syrup". The massecuites are purged in a closed centrifugal with exhaust steam and a little water added after the steam to help in cooling down the 1st or 2nd sugars before dropping. The crystallizer strike is purged with steam after 24 to 48 hours cooling, little or no water being used except to assist in cutting down "sticky" strikes during burnt-cane periods.

Sugar from No. 1 Strike will polarize 99.2, Ash 0.12, Glucose 0.20 and moisture 0.25. There will be found a gradual diminution of polarization and increase in ash and glucose in other sugars. The basis of sugar sales is a standard of 94 N. T. N. T. or "Net Titre" = Polarization minus 5 times the ash minus the Glucose. This figure has been gradually raised in past years from 88 to 90, and then to the present 94, on which the Government fixes the price of raws. Consequently our factory efficiency or co-efficient of work is based on this method. A Cuban sugar of 96.5 Polarization, 0.50 Ash and 0.90 Glucose would show 93.10 N. T. and thus be subject to penalty. The tendency of most Queensland factories is to produce a high-polarization low-ash sugar of 97.5 N. T. or better.

Mr. McAllep:

With respect to sugar polarization we are going through just the same stages as you were in Australia 25 years ago. Our results are confirming conclusions reached at the time that lead to manufacturing 98-99 polarization.

Dr. Van Harreveld:

In Java we make two raws. The brown raw for Japan is a dark sugar of color 12 to 14, called muscovado, darkened with caramel in the centrifugal. It is of 97.5 polarization. Another raw sugar for the refineries in Hong Kong and elsewhere is of color 16 to 20 and of 98.5 polarization.

Mr. Tarleton:

All mills in Cuba mix the first and second sugars in the bins before bagging.

We have only recently installed the double-purging system in one of our mills, only operating about one month so far; we have received no outturn results from the refineries, but the general appearance is very good and the filtering rate has improved. We are redrying the third sugar, mingling it with 2nd molasses and drying it without washing. The resulting sugar polarizes about 92 in comparison to about 75. This 92 polarization sugar is then used for seed after mingling with meladura. The run-off from the redrying gave a molasses of about 40 purity. This molasses was used for finishing off the "C" (or 3rd) massecuites. It had been our intention to wash the sugar which was being redried, but we found the resulting wash was too high and had to be boiled back in the second massecuite thereby causing a circulation of molasses.

Mr. McAllep:

Our first work on refining quality of sugar was size of grain. Possibly this may be termed the most important refining characteristic and one equally as important to the raw sugar manufacturer as to the refiners. Considerable additional pan capacity was installed to render the production of acceptable grain possible. A

sifting method for determining the size was developed and samples have been regularly tested at the Experimental Station. For some years this characteristic of raw sugars, as a whole, has been on a fairly satisfactory basis.

As to other chracteristics, each refiner's comments are from the point of view of his own equipment and process, so it is not strange that conflicting opinions will be received as to the refining value of any particular sugar.

The attention given to filtration rates has been due to a change in refining practice. Ten or twelve years ago the old bag filters used in connection with the defecation were in quite general use and filtration rate was of minor importance in comparison with the present time. Clearing up the liquors by filtration with Filter-Cel, however, prolongs the usefulness of the char and improves the quality.

We have done some work in two or three factories on double purging of low-grade sugar, but it has not been introduced commercially because we do not have sufficient machine capacity. Raw sugar at 70 or 73 purity is mixed with water and we get a run-off of about 50 to 55 and sugar of 90° without washing. Water was found advisable for mixing with the sugar. It is preferable if you can let your mixed-up sugar stand a little while before purging. If you have been using the two-boiling system, changing to a three-massecuite system saves a little time on your machines which could be used to do some double purging. However, it takes ten minutes or more to dry a machine-load under our condition.

Mr. Tarleton:

As a substitute for double purging, which requires extra centrifugals, we have thought of washing our "C" low-grade sugar before we drop it. This system would necessitate double canals for molasses and a device to shift from one canal to the other before applying the wash-water, and a steam-connection to keep the basket clear of the heavy low-grade molasses, otherwise we would catch some of this molasses with the washing and cause a circulation of molasses. I do not think that we would lose any time, for the sugar would discharge more easily. We could wash it up a little, say to the same purity as the sugar we get from double purging of sugar. It would then be very free and not nearly as hard to handle, and would probably discharge almost twice as fast.

Mr. McAllep:

The first point that came to our attention in Hawaii was filtration rate of the products. At first, raw melt only was filtered with Filter-Cel; later this practice extended to both raw melt and affination-syrup. Many of the United States refineries now filter all the affination-sirup, and many more filter as much of the affination-syrup as their equipment will permit. Probably few, if any, fail to filter the raw melt. Thus this characteristic has been brought to the front through a change in refinery practice. It is of the greatest importance where the affination-syrup is filtered. When raw melt only is filtered it is of much less importance.

Study of this characteristic was undertaken in Hawaii some four or five years ago. I will briefly summarize the results of this work. The material having the greatest retarding effect on filtration is what we might term permanent "Suspensions" and "Turbidities"; material finely enough dispersed to be accurately described as being in "Colloid dispersion" is too small in size to affect the keiselguhr. Particles of larger size such as bits of fiber have a negligible influence.

At least six factors affect the quantity of undesirable material in the sugar, as follows:

1. *Clarification.* If the hot limed juice is about 8.0 to 8.3 pH and settling is carefully conducted, there will be secured the clearest run-off possible to obtain from any particular juice.

2. *Formation of suspended matter during manufacturing operations.* This refers to the turbidity, largely due to organic matter, that forms subsequent to clarification. No practicable means for preventing the formation of this material has been suggested.

3. *Boiling methods.* It is prefereble to have as large a proportion of the sugar as possible crystallized from high-purity massecuites.

4. *Quality of low-grade sugar.* Improving the quality of the low-grade sugar returned to the massecuite either by filtration or by double purging will tend to improve filtration characteristics.

5. *Sugar polarization.* The foregoing factors refer to composition of the raw sugar. Filtration rates, under otherwise equal conditions may be improved by reducing the quantity of raw sugar, that is, by increasing the polarization.

6. *Quality of raw material.* The composition of the juices, particularly with reference to phosphoric acid content, influences the clearness of the juice that can possibly be obtained in clarification. There is also the greatest difference in the amount of suspended matter separated subsequent to clarification, in different juices. We have considerable information indicating that, at least in Hawaii, this is rather intimately associated with the ripeness of the cane.

Working along the above lines considerable improvement has been made in the filtration characteristics of Hawaiian sugar.

Mr. Lanier:

The filtration rate of sugar depends considerably on proper clarification of the juice and the obtaining of optimum clarification in liming to the extent where you get the highest rise in purity. I have been trying in practical use in the last couple of year to obtain optimum clarification by using the pH of defecated juice from 7.6 pH to 8.4 pH varying with the different qualities of the juice encountered. I get higher filtration rate from the sugars, and less fouling of heating surface in the evaporators. I am operating a factory that formerly could not run more than a week without cleaning and I have now run as long as two weeks without cleaning.

Mr. McAllep:

We used the Elliott Filtration test. We know it is not perfect, but it was the only thing available when we started on this work. After several years of observation, I believe that an improvement in a certain sugar as shown by the Elliott test will be reflected by an improvement in the filtration at the refinery. I have been very much in hope that this work of Dr. Paine, in which I am very much interested, will provide us with a really practical, direct means for correctly evaluating the refining value of our sugar. The Elliott test enabled us to make progress where otherwise we would have been without tools to work with.

Mr. Tarleton:

We have been experimenting with crystallizer cooling. We have installed several water-cooled crystallizers. Mr. Keller has some data that we would like to submit.

Mr. Keller:

The stationary-coil water-cooled crystallizer is what I saw in the Philippines, patented as the "K.W.W." (the initials of the men who made it) Criytallszer. The

stationary coils are 3/4" pipe spaced at distances as close as you can feasibly get them, say 16" apart. The vertical distance between bends on each coil is about 5" centers. We have all these coils connected on one header for water inlet and verything going to another header for the water outlet. That has been giving us very good results, but before I go any further I will say I would only advocate cooling-coils where you have insufficient cooling due to lack of capacity. Figures do not lend themselves to full comparison because to begin with our crystallizers are not yet arranged as the patentees claim they should be; our paddles are not properly placed. Each little space between coils, with its paddle, acts as an independent crystallizer as the massecuite moves to one side and then back. In cooling these crystallizers we found we could speed them up, something we have not done up to the present. Results can best be shown by a few averages, as follows:

CROP	BRIX	PURITY	FINAL MOLASSES	DIFF. PUR. MAS. & MOL.	SUC. F.M. % CANE	TEMP. DRIED	HOURS COOLED
24-25	96.38	56.47	34.33	22.14	1.275	—	About 48 hrs.
25-26	96.14	56.26	34.64	21.62	1.097	—	About 44 hrs.
26-27	94.61	56.68	30.82	25.86	.94	107	28 hrs. 12 min.

In the year 1926-27 six stationary cooling-coils were in use. We also ground 10% more cane, wherefore our Superintendent claims that he is certain that the molasses loss would have been higher than before, had it not been for the installation of the cooling-coils. Because they had the cooling-coil crystallizers they were able to allow those that had no coils to cool longer. The cooling-coil crystallizers are filled twice to the others once, giving the cooling-coil crystallizers twice the work. We expected we would have a little trouble with false grain, but we did not. Some strikes dried slowly, indicating reproduction, but we experienced no special difficulties. There is more study to be made of how and when the water should be turned on, and there is a lot more to learn.

We installed only one "Ragot" revolving-coil crystalliezr furnished by Cail (of France). The coil is a 4" coil, which revolves. On these massecuites they could not get quite as heavy a Brix as they wanted, because the massecuites had to be dropped through a pipe-line. The crystallizers in which the two types of coils were placed were of the same size and capacity.

Average of three strikess

CROP	BRIX	PURITY	F. M.	PUR. DIFF.	TEMP. DRIED.	HOURS COOLED
26-27	93.22	55.48	28.67	26.65	98	27 hrs. 30 min.

Our temperature of cooling-water was 95° to 100° F. We used condensing water due to shortage of well-water.

I might draw to your attention that these crystallizers were of the same size and that the crystallizer cooling surface was 694 square feet on the stationary coils and 645 square feet on the revolving-coil crystallizer. I might say in a general way that it looks as if you can expect an improvement of 3 to 6 points drop, depending on your conditions, in half the time.

We supplemented this work and experimented with the Ragot (revolving-coil) crystallizer, thinking we might make this revolving coil do pan-work.

We took an average of about 16 "B" strikes and did not have time do this on "A" strikes.

CROP	BRIX	PURITY	PUR. MOL	PUR. DIFF.	TEMP. DRIED	HOURS COOLED
24-25	95.78	67.75	47.29	20.46	——	————
25-26	96.01	69.72	48.96	20.79	——	————
26-27	95.22	69.31	41.14	28.18	126	5 hrs. 35 min.

The totals for the Crop of 1926-27 were with Ragot or French Crystallizers; the speed being 1 R.P.M. The stationary-coil crystallizers ran 1/5 to 1/4 R.P.M.; on individual tests we were able to obtain a 35° molasses (including the wash) from a 68° "B" strike, in seven hours. I am sure that by separating the run-off and wash there is a possibility of making a final molasses from what we now consider a "B" or second massecuite; this will allow reducing the amount of sugar in process. When we do this we will reduce the present errors of estimating, reduce our insurance and possibly may do away with some equipment.

If our crystallizer-sugars from coil crystallizers were cooled over 30 hours, at times they dried slowly; probably they were "reproduced" to some degree. Our men report better drying of cooled sugars. The physical character of the material seemed to be different and our men reported the sugars as being freer.

Mr. Lanier:

I woul like to get some figures on the drying quality as compared to hot. The colder the C sugar the freer drying.

In crystallizers in Louisiana where the C massecuites were dropped hot and cooled too suddenly it was found to cause false grain in the crystallizers. I have never found this trouble in Cuba, but I suppose it depends entirely on the nature of the purity of these C massecuites and their impurities, glucose and saline.

Mr. McAllep:

Discussing this matter of the speed of crystallization and the danger of formation of false grain, I think we must remember that we are working with quite a number of variables. We have the purity to which we boil, the speed of cooling, the amount of crystal surfaces and size of grain in conjunction. With experimental apparatus at the Sugar Planters Experiment Station, in one series of tests, we found that in 3½ days we reduced a certain molasses to about 27° gravity purity. The lowest purity which we obtained in that molasses was only a few tenths lower. This molasses was very much lower in purity than could possibly be separated in factory practice. The test proved the crysatllization of the sugar was more rapid than a good many of us believed. Our massecuites can remain in the crystallizer from egiht or nine days to two weeks. That capacity could be cut down by the use of proper cooling coils.

He have come to use a microscope to a great extent in the factories, even allowing the pan men to have them. We use a very cheap compound microscope, giving 50 diameters. In the eye-piece, we put a disc micrometer with 0.5 mm. ruling; this divides the field into spaces of 0.1 mm. each. Such equipment makes quite a material improvement in the work. The outfit costs $40.00 to $60.00 and in many cases has proven a very satisfactory investment. When we get together in a meeting we can talk about the size of grain in definite figures.